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AN ASSESSMENT OF THE 4X HADDOCK STOCK FOR THE 1962-80 PERIOD

by

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Abstract

Recent reported landings of 4X Haddock (26-28,000 mt) have been considerably in excess of the long term average (10-20,000 mt). The catches are thought to be even higher on account of high discarding and misreporting which is suspected to have occurred.

The seasonal pattern of exploitation by fleet components has also changed. The offshore fleet, which prior to 1977 was operational year round, now only fishes in the early spring and late fall, on account of their management plan. The inshore fleet is presently reporting the dominant amount of the catch. This shift in fleet dominance is causing problems in obtaining adequate sampling coverage of the catch.

Both the U.S. and Canadian bottom trawl surveys indicate dramatic increases in stock size during the 1974-78 period. However whereas the Canadian survey shows continuing increases to 1980, the U.S. surveys shows either a leveling off or slight decrease in stock abundance.

Two forms of sequential population analysis were used to describe stock dynamics during the 1962-80 period. Both used the Canadian survey series only in tuning the analysis. The first employed the Survivor Method of Rivard (1980) while the second employed procedures previously in use. Both methods derived a 1980 fully recruited fishing mortality of 0.3 which is slightly above $F_{0.1}$ (0.284). However, the calculated sizes of the 1974 and 1977 year-classes were significantly different between the two methods. The more conservative estimates were chosen for both of these year-classes.

Projections to 1982 were carried assuming a 1981 catch of 28,000 mt and $F_{0.1}$ exploitation for 1982. Age one recruitment for 1980 was set at 100×10^5 and 40×10^5 for 1981-82. The 1982 projected catch was determined to be 32×10^3 mt.

Résumé

Les récents rapports de débarquements d'aiglefin de 4X (26-28 000 tm) sont de beaucoup supérieurs à la moyenne à long terme (10-20 000 tm). On croit que les prises sont même beaucoup plus élévées, à cause des grandes quantités rejetées à la mer et des faux rapports qu'on est en droit de supposer.

Le déploiement saisonnier des composants de la flottile a également changé. La flottille de grande pêche qui, avant 1977, pêchait à l'année longue, ne pêche maintenant qu'au début du printemps et à la fin de l'automne, pour se conformer aux plan de gestion. La flottile côtière est à l'heure actuelle celle qui rapporte la majeure portion des prises. Ce changement dans la répartition des prises rend difficile un échantillonnage adéquat des prises.

Les relevés par chalut de fond, tant américains que canadiens, indiquent des augmentations dramatiques des effectifs du stock pendant la période 1974-78. Cependant, alors que les relevés canadiens indiquent des augmentations continues jusqu'en 1980, les relevés américains montrent soit un plateau, soit une légère diminution.

Deux formes d'analyse de population séquentielle ont été utilisées pour décrire la dynamique du stock pendant la période 1962-80. Pour l'ajustement précis des deux formes, seule la série des relevés canadiens a été utilisée. La première forme d'analyse est fondée sur la méthode des survivants de Rivard (1980), tandis que la seconde utilise les méthodes traditionnelles. Les deux méthodes donnent une mortalité par pêche au plein recrutement de 0,3 en 1980, légèrement supérieure à $F_{0,1}$ (0,284). Cependant, elles donnent des résultats significativement différents dans le calcul des effectifs des classes d'âge de 1974 et 1977. Nous avons choisi les estimations les plus conservatrices de ces deux classes d'âge.

Des prédictions jusqu'en 1982 on été effectuées, en supposant des prises de 28 000 tm en 1981 et une exploitation à $F_{0,1}$ en 1982. Le recrutement d'âge 1 en 1980 a été fixé à 100×10^6 et à 40×10^6 en 1981-82. Les prises prévues en 1982 sont de 32×10^3 tm.

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INTRODUCTION

Biological assessment of this stock has been carried out since the mid 1960's. Sequential Population Analysis (SPA) was first employed by Halliday in 1974 to determine the population structure and exploitation rates in the current year. Since 1977, the U.S. and Canadian groundfish bottom trawl survey data have been extensively used to tune the SPA. Much of this tuning has necessarily depended on subjective decisions by the assessment biologist. Rivard (1980) has recently introduced a technique referred to as the Survivor Method to make the tuning of the SPA with the research survey data a more objective process.

This document presents an analysis of the 4X haddock stock structure during the 1962-80 period based on both the Survivor Method and the older procedures used to tune an SPA. Yield projections were made to 1982 using the $F_{0.1}$ exploitation rate for 1982.

TRENDS IN REPORTED LANDINGS AND RECENT MANAGEMENT HISTORY

From the early 1930's to the early 1960's, reported landings of the NAFO Division 4X haddock stock fluctuated between 10-20,000 mt annually (Figure 1). These landings were split equally between Canada and the U.S. During this period, the major part of Canada's catches was landed by longliners while the U.S. landings were almost wholly reported by otter trawlers. In 1963, the USSR first entered the fishery, reporting a catch of 400 mt (Table 1). Their involvement in the fishery increased until 1966, when they reported catches of 10,065 mt. However, subsequent to this, they did not undertake directed fishing on 4X haddock. During the same period, the Canadian otter trawl fleet expanded rapidly, with a particularly large increase in the number of vessels in the tonnage class 4 category (Figure 2). As well, tonnage class 5 vessels entered the Canadian fishery (Table 4) for the first time in 1966.

The increased effort in the fishery resulted in peak reported total landings from the stock of 37,116 mt in 1966. Catches remained close to or above 30,000 mt until 1969. The high exploitation rates generated during the late 1960's provoked dramatic declines in stock abundance which in turn resulted in the establishment of a TAC and restricted fishing area regulations in 1970.

In both 1970 and 1971, the TAC was set at 18,000 mt. No bottom trawling was allowed on Brown's Bank during March-May. In the following two years, the TAC was reduced to 9,000 mt with similar area restrictions. In 1974, 4X was closed to directed fishing on haddock altogether and managed through by-catch regulations. Limitations on total haddock landed per fishing trip were continued in 1975 in an attempt to control exploitation rates. These have continued in varying forms to the present. Since 1976 the offshore fleet allocation has been divided into sub-annual quotas in an effort to regulate fishing pressure throughout the year. By 1975 and 1976, discards were becoming an increasingly important problem. In 1977 and 1978, the TACs were overrun by considerable margins (Table 1) despite all the regulations.

Belzile (1978) estimated that in the springs of 1977 and 1978, the offshore fleet encountered large by-catches of haddock, particularly while fishing for pollock, and discarded approximately 10% of the total catch. No reports on discard patterns in 1979 and 1980 are available.

Since 1975, misreporting of haddock by species (particularly by the inshore fleet) and by area (particularly by the offshore fleet) has become increasingly evident. No data exist which can provide estimates on the level of these catches.

The trends in the fishery since 1975 suggest that the fishermen have had a difficult time staying within the established TACs, particularly in 1977 and 1978. Consequently the catches shown in Table 1 are most likely conservative, although by how much is impossible to determine.

As well, since 1979, the offshore fleet allocation has continually declined while that for the inshore fleet has slightly increased (Table 2). As can be seen from Figure 3 and 4, this has led to an overall change in the exploitation strategy of the fishery. The smaller vessels of the inshore fleet, which cannot fish in the early spring and late fall, due to weather restrictions, are replacing the larger offshore vessels during the summer months. The offshore vessels, which are almost exclusively TC 4 and 5 otter trawlers, are now fishing in the early spring and late fall, whereas previously some summer fishing had occurred. As will be seen below, this has implications on the interpretation of the commercial catch rate data.

COMMERCIAL CATCH-AT-AGE COMPOSITION

Previous analyses (Halliday and McCracken, 1970; McCracken, 1956, 1960) have indicated that catches reported from Unit Area 4Xs are likely from the NAFO Division 5Y haddock stock. These landings were therefore excluded from the present assessment.

The age composition of landings from the NAFO Division 4X haddock stock were constructed for the 1962-80 period. It has been observed (Hennemuth et al., 1964) that Unit Area 4Xr haddock landings have a substantially different size and age composition from those reported from 4Xmnopq. Consequently, sampling data from these two areas were applied separately to the respective catches in construction of the removals at age table.

Canadian commercial samples were applied to Canadian landings whenever possible. Generally, otter trawl samples were applied to landings reported by otter trawlers, danish seiners and shrimp trawlers. Longline samples were applied to combined longline and gillnet landings.

USA landings compositions for 1962-64 were taken from Schultz and Halliday (MS 1969) while from 1965 to the present, Canadian samples were applied to USA landings. This should not introduce major errors since landings from both countries have been similar in age composition (Hennemuth et al., 1964) and USA landings have been only a small proportion of total reported catch during the 1965-80 period.

No commercial samples for the 1962-76 period are available for the USSR and Spanish landings. The age composition of these catches was assumed to be the same as that of Canada.

On Tables 3 and 4 are indicated the number of samples that have been taken by gear category and tonnage class. Although the coverage by gear has been good, the small vessels have consistently been undersampled. This problem is becoming more acute since the smaller vessels are now reporting the predominant proportion of the catch.

It is impossible to state at this time whether or not the catch composition for the small vessels differs from that for the large vessels. The present assessment has assumed them to be the same.

The generated removals-at-age are given in Table 5 and the percent age composition, by numbers and weight, are given in Table 6. These numbers do not include any correction for discarding as the age structure of the discarded and misreported catches is not well known. During the early 1960's, the 1959 and 1960 year-classes supported the fishery. In the subsequent years of high exploitation rates, the 1962 and very large 1963 year-classes supported the fishery. The latter remained an important component of the landings until 1972. During the mid 1970's, when the stock appeared to be recovering, the 1969 and 1971 year-classes contributed significantly to the landings. Since 1977, the 1974 and 1975 year-classes have become increasingly important to the fishery. In 1980 they contributed 28 and 33% by weight respectively to the landings.

The weights-at-age derived from the commercial samples are given in Table 7.

These are derived solely from Canadian sampling information.

STOCK ABUNDANCE TRENDS

A. Commercial Statistics

In previous assessments, the Canadian T.C. 4 otter trawl catch rates have been used as indicators of trends in abundance. The equivalent series for the U.S. fleet is only useful up to 1977. Now, due to the changing seasonal pattern in exploitation by the various fleet components, it seems that the Canadian series may be suspect. Two alternate series of catch rates for the Canadian T.C. 3 vessels - one for side and one for stern trawlers - were then developed. The means of the July-October catch rates for each year by vessel type are given in Table 8 and illustrated in Figure 5. Although there is considerable variation in the data, there is a general trend of increasing stock abundance over the 1972-80 period.

However, due to the changing nature of the fishery and the extensive regulation present, it was felt that these trends can only be considered in the most general way and could not be used to assist in tuning of the sequential population analysis.

B. U.S. Fall Bottom Trawl Survey Data

The NMFS at Woods Hole has been running a standardized bottom survey on the east coast since 1963. The strata sampled in NAFO Division 4X (31-34, 41 and 42) are illustrated in Figure 6a. The stratified mean catch-at-age in numbers per tow for other strata are presented in Table 9. As was discussed in O'Boyle (1980), strata 41 and 42 were not sampled by the survey during 1963, 1964, 1976, 1978, 1979 and also 1980, although significant amounts of haddock have been caught in these two strata in other years. The catches-at-age were thus recalculated with strata 41 and 42 removed for the whole time series (Table 10).

C. Canadian Summer Bottom Trawl Survey Data

MFD at St. Andrew's has been conducting a standardized bottom trawl survey every July-August since 1970. The stratified mean catch-at-age in numbers per tow for this data set are given in Table 11.

A ranking of the catch rates by strata is given in Table 12. It is evident from this that, during July-August, haddock concentrate primarily on Brown's Bank and secondarily in the Roseway Bank area. The highest concentrations in the last two years of the survey were actually observed just in the mouth of the Bay of Fundy. This stratum 90, is not sampled by the U.S. survey. It will be interesting to see if stratum 90 is an important area of capture during the 1981 survey.

A preliminary analysis of the variation in the survey data was undertaken in an attempt to see how precise the survey is. The contribution of each stratum to the overall stratified mean catch rate and the variance was determined as per White et al., (1981). The results of this analysis are given in Table 13. It can be readily seen that in general few strata determine the overall catch rates as used in the assessment. In one year, 1977, one tow in stratum 76 heavily influenced the overall survey results. These data warrant considerable further study. For the present assessment, the observed catch rates were taken as indicative of abundance trends in the stock.

D. Comparison of Abundance Trends from the Canadian and U.S. Research Surveys

The mean stratified catch per tow in numbers and weight for each survey were treated with a three year median smooth procedure. The results of this smooth are given in Table 8 and illustrated in Figure 7. In the latter, the original or "rough" data are shown for comparison.

Since 1970, both surveys show very similar trends. The main difference between the two data sets is that whereas the Canadian survey indicates an increase in stock size in 1980, the U.S. survey indicates a stabilization in the numbers per tow and a decrease in the weight per tow. Both surveys do, however, indicate that the catch rates in numbers are presently 3-4 times those obtained in 1970 while the catch rates in weight are now 2-3 times those obtained in 1970.

SEQUENTIAL POPULATION ANALYSIS

Two procedures were followed to obtain estimates of the population structure and exploitation rates in 1980. The first involved applying the Survivor Method of Rivard (1980) to the catch-at-age and survey data to obtain estimates of the stock size for ages 2-9. These data were then input into a cohort analysis to obtain a stock structure for the 1962-80 period.

The second method involved utilizing the survey information in cohort analysis as has been done previously i.e. linearity between cohort analysis results and survey data taken as the criterion for good fit.

A. Determination of the Terminal Fishing Mortalities for 1980 - the Survivor Method

A complete description of the Survivor Method is given in Rivard (1980) so it will not be repeated here. However as the procedure has never before been used in a standard assessment, the details of its application will be discussed.

When a preliminary survivor run was carried out on the U.S. survey data, the predicted population sizes were found to have very large coefficients of variation (400-500%). The reason for this is not apparent. Preliminary survivor runs on the Canadian data exhibited coefficients of variation which were considerably less (30-80%). Therefore, for this assessment, only the Canadian survey data as provided in Table 11 was utilized.

The first step in the method was examination of the data in Table 11 to determine what ages were most likely linearly related to population numbers-at-age. Data for ages 10-13+ were dropped as it was felt that the low numbers being sampled would lead to the generation of spurious relationships.

The second step was to determine the optimum size of the calibration block. The standard deviation of the overall residual was used as the optimizing criterion, along with the CV-at-age and the total number of residuals (Table 14). To determine the block size, the procedure was run with a small calibration block and then this was systematically increased both in number of years and ages. Each run provided the estimated survivors for the succeeding run. From these runs, two things were determined. First, the survivor estimates were most accurate for a data set with ages 3-8 only. Second, a calibration block with a final year and age of 1979 and 7 respectively gave the lowest standard deviation of the residuals.

The pattern of K over age was also examined. When K was allowed to level off at 8, the oldest age in the analysis, there was some evidence to suggest that K first decreased to a minimum around age 6 and then increased up to age 9. From preliminary cohort runs, the partial recruitment patterns in the commercial fishery could not be determined as being dome-shaped. This was taken as evidence that K most likely does level off in the older age groups, here chosen to be age 6.

Next, a run of survivor was made, using a calibration block with a final year and age being 1979 and 7 respectively and K leveling off at age 6 (Table 15). The mid-year population estimates-at-age from the survivor run were plotted against the research survey estimates to examine inconsistencies in the data set (Figure 8). Fits for ages 4-8 were very good but not so good for age 3.

Fishing mortalities for ages 3-8 for 1980 were then calculated by inputting the survivor estimates and catches-at-age into a Newton-Raphson interative solution to the Baranov catch equation. The fact that the survivor estimates are end of the year values was taken into account.

One final survivor run was made using the same final year and age for a calibration block but including data for ages 2 and 9. The calculated age 2 survivor estimate and hence fishing mortality was used in later analysis, although its estimate was not as reliable as those for ages 3-8.

Finally, the generated pattern of fishing mortality-at-age was examined for determination of the partial recruitment-at-age. The age 6 estimate of 0.72 was extremely high as was the CV-at-age (84%). The value was felt high as the survivor procedure fit the other points for that particular year-class reasonably well. Thus it appears likely that either the catch-at-age or the survey data for age 6 in 1980 is bad. Full recruitment was taken to be at age 6 and asymptotic thereafter. The fully recruited F was taken at 0.315, the fishing mortality on age 7. The partial recruitments for ages 2-5 was determined by dividing the survivor-derived fishing mortalities by 0.315.

B. Determination of the Terminal Fishing Mortalities for Age 12 in all Years

In the two cohort runs to be described below, the fishing mortalities for age 12 were determined by the iteration method. Initial F's of 0.3 were input and the fishing mortalities for ages 5-8 averaged and reentered at age 12. This iteration was continued until the F at age 12 changed less than 0.001 per iteration. Normally 4-5 iterations were required.

Whenever changes were made to the 1980 F's-at-age, the F's at age 12 were reiterated.

C. Cohort Analysis with Survivor Derived F's for 1980-Option 1

Table 16 presents the results of a cohort analysis run using a 1980 F_7 of 0.315 and the survivor-derived partial recruitment pattern for age 2-9. The partial recruitments for age 10-12 were taken as 1 while the PR for age 1 was arbitrarily chosen as 0.0003.

The plots in Figures 9 and 10 were used to determine how well the cohort analysis predicted population estimates fit the estimates derived from the research data. For Figure 9, the research numbers-at-age were multiplied by the survivor-derived K's-at-age to obtain absolute estimates

of population size, which could be directly compared to the cohort analysis results.

Figure 10 shows the three standard relationships that were also examined, these being:

1. Summation of age 3 to 8 numbers from the cohort analysis versus the summation of ages 3 to 8 research survey catch rates.
2. Age 2 + 3 from the CA versus age 2 + 3 (standardized to 1970-80 mean) from the research survey data for each year-class.
3. Age 3+ population biomass from the cohort analysis versus the Canadian Otter Trawler T.C. 4 catch rate.

In all these relationships the CA numbers were adjusted to obtain mid-year estimates for comparison with the research survey data.

The relationships indicated that the fit was quite good but could be improved if the partial recruitment on ages 3 and 4 was raised.

D. Cohort Analysis using Standard Procedures Option 2

It was decided to see if the standard procedures employed previously would give the same or a different answer to that derived by the Survivor Method.

First, a set of relationships was chosen on which to tune the CA, these being:

1. Age 2 + 3 CA vs age 2 + 3 from survey data for each year-class. Here, the standardized (to 1970-80 mean) survey estimates were averaged rather than just sumed as was done above.
2. Age 2-5 from CA vs age 2-5 from survey data. Here the smoothed (by median) survey data was used. This series is illustrated in Figure 11. As well, the CA estimates were converted to mid-year values.
3. Age 6+ from CA vs age 6+ from survey data. As with the above relationship, the survey data were smoothed (Figure 11) and the CA estimates converted to mid-year values before the data were examined.
4. 3+ Population Biomass from CA vs Canadian OT 4 catch rates. Again, the CA estimates were converted to mid-year values.

Next, a preliminary partial recruitment pattern for 1980 was estimated by determining, from catch curves, full recruitment to be at age 6, a low partial recruitment of 0.0003 at age 1 and a linear progression in PR between ages 1 and 6. Recruitment was assumed to be asymptotic after age 6.

Then a series of cohort analyses were run with varying F_R's for 1980 of 0.2-0.5, in increments of 0.05. The resulting correlation coefficients for the four relationships are given in Table 17. It is evident from this that the relationships are relatively insensitive to variations in the terminal fishing mortality. A fishing mortality of 0.3 does optimize two of the first three relationships, albeit marginally, and was thus chosen as the run which best represents stock status with this procedure.

Minor adjustments were also made to the 1980 PR to allow optimization of the year-class strength estimates.

The results are given in Table 18 and Figure 12.

F. Final Cohort Analysis

Table 19 presents an overview of the year-class sizes-at-age one as determined by this and previous assessments. The present assessment's age one estimates are remarkably similar to those determined in previous years. However, between the two options presented above, the sizes of the 1974 and 1977 year-classes are significantly different.

Previous estimates of the 1974 year-class at age one have been closer to 50 x 10^6 than the 70 x 10^6 as determined by Option 2. Thus the age one estimates for this year-class were taken from the Option 1 calculations.

The Survivor Method predicted the size of the 1977 year-class at age one to be 93 x 10^6, compared to 76 x 10^6 for the standard procedure. The survivor estimate was based on only one survey data point while the second estimate was based on two. For this reason, the latter value for the 1977 year-class at age one was chosen.

The final cohort analysis run is given in Table 20. The pattern in production (Rivard, 1980) over the 1962-80 period for this cohort analysis is provided in Figure 13. It can be immediately seen that much of the more recent production is due to growth by incoming large year-classes during the 1973-80 period. Indeed, the present analysis suggests production due to growth has never been higher.

YIELD PROJECTIONS TO 1982

A. Yield Per Recruit Model

The three input parameters to the yield per recruit model are weight-at-age, partial recruitment and natural mortality. Both the first two are known to have undergone considerable changes over the time period covered by the present analysis. Discussion here will be restricted to the changes observed in the partial recruitment pattern.

Figure 14 illustrates the partial recruitment patterns determined for three year intervals from the final cohort analysis run. The age at full recruitment has varied between 4 and 7 with it presently being estimated at age 6 (Figure 15). When one compares the pattern in change of age at

50% recruitment (Figure 16) to the pattern in change in population biomass and production (Figure 17), one finds a possible direct relationship - the larger the population, the older the fish recruits to the fishery. It is encouraging to see then that the presently determined age of full recruitment, age 6, is quite old and near the upmost extreme, age 7, exhibited for the 1962-80 period.

These variations in the partial recruitment cause considerable variation in the calculated $F_{0.1}$. Using mean weights-at-age for the 1962-80 period, $F_{0.1}$ values were calculated for a period when the stock size was high (1962-64), when it was low (1971-73) and at its present size. The results are given in Table 21. The $F_{0.1}$ values vary between 0.256 and 0.313 which could be considered limits to its variation due to changes in the partial recruitment.

For the present assessment, mean weights-at-age for the 1978-80 period were used in the calculation of the $F_{0.1}$. When this is done, the $F_{0.1}$ is determined to be 0.284, a considerable drop from the 0.304 determined with different weights-at-age. According to this calculation, which is taken to be more indicative of recent events, the current exploitation rate of 0.3 is above $F_{0.1}$.

B. Catch Projections to 1982

Using the 1980 stock status as outlined in Table 22, projections to 1982 were carried out, assuming a 1981 catch at the TAC level of 28,000 mt and fishing at $F_{0.1}$ (0.284) in 1982.

The size of the 1979 year-class at age one was, from both the U.S. and Canadian surveys, shown to be 3.2 times the 1970-80 average. This provided an estimate of 150×10^6 in 1980. As this estimate is based on a small number of observations and as the estimated size of the year-class rivals the extremely large 1963 year-class, it was decided to discount the year-class estimate by an arbitrary amount. A figure of 100×10^6 was used which is about equal to the size of the second largest year-class in the data series--that of 1962.

Age one recruitment for 1981 and 1982 was taken to be 40×10^6, similar to value used by O'Boyle (1980) and approximately average for recent recruitment values.

The results of the projection are presented in Table 23. It is seen that the 1982 TAC could be set at 32×10^3 mt. There is some evidence to suggest that the estimates of both the 1977 and 1979 year-classes are conservative in the present analysis. If this is the case, then the 1982 yield could be in excess of 32×10^3 mt fishing at $F_{0.1}$. Nevertheless, given the degree of uncertainity in the estimates, the more conservative figures presented here appear more appropriate.

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Table 1. Reported Nominal catches (mt round) of haddock from NAFO Division 4X (excluding unit area 4Xs) by country.

YEAR	CANADA (Ma)	CANADA (Nfld)	USA	USSR	SPAIN	JAPAN	OTHER	TOTAL	QUOTA
1962	10118		5761					15879	
1963	14385		6397	400			28	21210	
1964	24468	12	7612	1108			40	33240	
1965	20562		2455	2582				25599	
1966	25492	23	1393	10065	143			37116	
1967	29098	46	2937	199	78			32358	
1968	27277		2858	335	116		36	30622	
1969	27419		1707		478		19	29623	
1970	15561		1639	2	370	12		17584	18000
1971	16064		656	97	347	1		17165	18000
1972	12394		411	10	470		1	13286	9000
1973	12580		268	14	134	6		13002	9000
1974	12434		662	35	97			13228	0
1975	16509		2109	39	7		2	18666	15000
1976	16338		972		95		5	17410	15000
1977	19537		1649	2			12	21200	15000
1978	25356	114	1134	2		16	11	26633	21500
1979	24260	268	69	3		15		24615	26000
*1980	28177	75	256			34		28542	28000

* Provisional 25/4/81

Table 2. Recent Canadian fishery allocations and the respective reported catch in metric tons for 4X haddock. (unit areas M-R)

Year	Vessel Size	Allocation	Reported Catch	% of Allocation
1975	all vessels	12,500	16,509[1]	132
1976	all vessels	13,300	16,338[1]	123
1977	all vessels	13,400	19,537[1]	146
1978	all vessels	21,500*	25,356[1]	118
1979	> 125 ft.	8,500	8,687[2]	102
	< 125 ft.	17,500*	15,515[2]	89
1980	> 125 ft.	5,500	7,518[2]	137
	< 125 ft.	22,500	20,659[2]	92
1981	> 125 ft.	4,600	3,336[3]	73
	< 125 ft.	20,600	4,050[3]	20

* Closed Fisheries

[1] Maritimes and Quebec

[2] Maritimes

[3] 15 April 1981 Atlantic Quota Report

Table 3. Reported nominal catches (mt round) of haddock from NAFO Division 4X (all unit areas combined) for Canadian (Maritimes and Quebec) fishery by gear type.

( ) - number of samples taken by MFD.

YEAR	OTTER TRAWL SIDE & STERN	LONGLINE	MISCELLANEOUS GEARS	TOTAL
1962	7813(2)	3724(1)	-	11537
1963	12063(6)	4700(9)	-	16763
1964	20532(8)	5799(10)	-	26331
1965	18048(14)	4692(2)	-	22740
1966	25800(12)	3720(3)	-	29520
1967	28696(37)	3108	162	31966
1968	25515(42)	2997	325	28837
1969	24333(52)	3302	439	28074
1970	11750(23)	3907	355	16012
1971	12152(20)	3940(3)	312	16404
1972	7639(22)	4048(7)	883(1)	12570
1973	6123(16)	5853(9)	704	12680
1974	5688(9)	6211(10)	535(1)	12434
1975	10567(43)	4944(8)	548(1)	16059
1976	10505(35)	4642(6)	1191(2)	16338
1977	14464(70)	4032(8)	1097	19593
1978	17437(49)	6052(10)	1966(4)	25455
1979	18776(35)	4347(12)	1430(2)	24553
1980	20685(34)	5338(17)	2543(4)	28566

Table 4. Reported nominal catches (mt round) of haddock from NAFO Division 4X (all unit areas combined) for Canadian otter trawl fishery by by tonnage class.

( ) - number of samples taken by MFD.

YEAR / TONNAGE CLASS	VESSEL SIZE (TONS) 0-50 1&2	51-150 3	151-500 4	500+ 5	NK	TOTAL
1962	5224(1)	1973	432(1)	-	184	7813
1963	5926	3230(3)	2863(3)	-	44	12063
1964	3118	3964(3)	13450(5)	-	-	20532
1965	4605	4182(2)	9261(12)	-	-	18048
1966	8872	9094	7648(12)	186	-	25800
1967	7479(2)	7983(1)	11085(31)	2149(3)	-	28696
1968	4753(1)	6938(5)	10552(34)	3272(2)	-	25515
1969	2619	4144(6)	9791(36)	7779(10)	-	24333
1970	2050	3165(1)	3703(20)	2832(2)	-	11750
1971	1715	2714(2)	4773(12)	2950(5)	-	12152
1972	1196	1688(2)	2811(17)	1944(3)	-	7639
1973	919(2)	971	2569(11)	1664(3)	-	6123
1974	2165(2)	1895(2)	1072(5)	556	-	5688
1975	2742(2)	3419(10)	2413(19)	1993(9)	-	10567
1976	1778(1)	2598(1)	3029(22)	3100(11)	-	10505
1977	2672(2)	3543(4)	3627(33)	4622(31)	-	14464
1978	4424	4923(1)	4045(35)	4045(13)	-	17437
1979	4684	5455(2)	4317(21)	4320(12)	-	18776
1980	6781(6)	6431(4)	3537(13)	3936(11)	-	20685

Table 5. Catch at age (Numbers x 10^{-3}) of haddock from 4Xm-r (excludes discards)

AGE	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	-	-	-	-	-	-	-	-	-	-	41	150	1	37	18	2	-	-	12
2	139	713	155	70	219	22	665	10	1055	788	22	3077	694	2175	1296	1285	75	81	168
3	4524	2013	1272	3038	18341	515	297	2016	724	1617	3434	113	4653	4568	1644	3126	3354	1158	2692
4	1415	7185	4286	1981	9796	20380	1164	1968	1502	788	1841	2247	309	5164	4261	2019	7014	6709	3283
5	1778	3087	9337	3153	3167	9148	17448	1621	379	1422	509	1067	1779	485	3682	3193	2094	3881	5321
6	1708	1649	3018	5409	2149	1039	4684	11243	524	404	645	527	509	1103	434	2881	2832	1070	3457
7	1648	1415	1492	1973	3747	735	713	3220	4536	69	90	600	189	247	807	360	1040	1244	578
8	973	593	1370	1000	840	1052	518	455	1863	3316	57	322	269	172	154	389	137	263	526
9	645	473	612	745	409	187	672	249	133	1020	1166	259	186	62	71	107	107	57	173
10	232	152	416	288	424	102	190	194	96	163	512	614	269	32	95	72	26	68	36
11	205	113	297	203	88	90	131	172	175	181	26	55	552	165	39	23	9	11	24
12	64	59	168	114	62	23	65	94	27	146	193	13	24	229	103	8	6	-	9
13+	100	43	36	113	84	81	89	69	37	105	92	6	4	11	157	87	48	18	16
Total	13431	17500	22459	18087	39326	33374	26636	21311	11051	10019	8628	9050	9438	14450	12761	13552	16742	14560	16295
Estimated Landings	18949	22806	32172	25910	39116	33494	31903	28435	16414	16235	13054	12095	13030	17318	18651	20557	26812	24678	28677
Reported Landings	15879	21210	31240	25599	37116	32358	30622	29623	17584	17165	13286	13003	13228	18666	17410	21200	26633	24615	28542

Table 6. Composition of commercial catch for 4X haddock fishery

AGE	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
A. PER CENT BY NUMBER																			
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	1.66	0.01	0.26	0.14	0.01	0.00	0.00	0.07
2	1.03	4.07	0.69	0.39	0.56	0.07	2.50	0.05	9.55	7.78	0.25	34.00	7.35	15.05	10.16	9.48	0.45	0.56	1.03
3	33.68	11.50	5.66	16.80	46.64	1.54	1.12	9.46	6.55	16.14	39.80	1.25	49.30	31.61	12.88	23.07	20.03	7.95	16.52
4	10.54	41.06	19.08	10.95	24.91	61.07	4.37	9.23	13.59	7.87	21.34	24.83	3.27	35.74	33.39	14.90	41.89	46.08	20.15
5	13.24	17.64	41.57	17.43	8.05	27.41	65.51	7.61	3.43	14.20	5.90	11.79	18.85	3.36	28.85	23.56	12.51	26.66	32.65
6	12.72	9.42	13.44	29.91	5.46	3.11	17.59	52.76	4.74	4.03	7.48	5.82	5.39	7.63	3.40	21.26	16.92	7.35	21.22
7	12.27	8.09	6.64	10.91	9.53	2.20	2.68	15.11	41.05	0.69	1.04	6.63	2.00	1.71	6.32	2.66	6.21	8.54	3.55
8	7.24	3.39	6.10	5.53	2.14	3.15	1.94	2.14	16.86	33.10	0.66	3.56	2.85	1.19	1.21	2.87	0.82	1.81	3.23
9	4.80	2.73	2.72	4.12	1.04	0.56	2.52	1.17	1.20	10.18	13.51	2.86	1.97	0.43	0.56	0.79	0.64	0.39	1.06
10	1.73	0.87	1.85	1.59	1.08	0.31	0.71	0.91	0.87	1.63	5.93	6.78	2.85	0.22	0.74	0.53	0.16	0.47	0.22
11	1.53	0.65	1.32	1.12	0.22	0.27	0.49	0.81	1.58	1.81	0.30	0.61	5.85	1.14	0.31	0.17	0.05	0.08	0.15
12	0.48	0.34	0.75	0.63	0.16	0.07	0.24	0.44	0.24	1.46	2.24	0.14	0.25	1.58	0.81	0.06	0.04	0.00	0.06
13+	0.74	0.25	0.16	0.62	0.21	0.24	0.33	0.32	0.33	1.05	1.07	0.07	0.04	0.08	1.23	0.64	0.29	0.12	0.10
B. PER CENT BY WEIGHT																			
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.33	0.00	0.05	0.02	0.00	0.00	0.00	0.01
2	0.41	1.56	0.24	0.10	0.17	0.02	0.77	0.02	3.66	2.43	0.08	12.97	2.45	6.53	3.61	2.88	0.13	0.17	0.32
3	17.91	6.89	2.97	7.62	31.42	0.95	0.58	5.32	3.97	9.56	23.68	0.70	29.28	21.63	7.14	10.80	10.83	4.10	8.41
4	8.59	33.08	13.32	7.65	21.29	51.72	3.28	6.09	9.61	6.07	19.04	23.22	2.61	35.78	27.19	11.98	34.85	36.07	15.06
5	13.14	19.63	37.73	14.60	9.96	28.68	60.16	6.56	2.68	12.26	6.24	15.88	23.21	4.34	31.59	26.72	14.46	28.95	32.54
6	14.42	12.29	15.95	32.57	8.24	4.50	19.09	53.38	4.57	3.73	8.65	8.71	8.99	14.33	4.89	30.83	24.57	10.23	28.30
7	19.13	11.48	9.04	14.85	17.24	3.95	3.80	18.12	45.60	0.74	1.31	10.91	3.63	4.06	12.76	5.15	10.46	14.25	5.77
8	10.89	6.11	8.69	8.49	4.68	6.44	3.33	3.20	22.13	39.83	0.92	6.12	5.37	2.98	2.89	6.24	1.73	3.52	6.07
9	6.47	4.72	4.76	5.61	2.61	1.32	4.84	2.15	1.86	14.45	20.54	5.35	4.00	1.15	1.37	1.86	1.51	0.93	2.23
10	2.94	1.47	3.10	2.92	2.71	0.82	1.50	1.71	1.65	2.66	10.98	13.71	6.09	0.64	1.94	1.32	0.41	1.15	0.52
11	3.09	1.34	2.23	1.96	0.62	0.73	1.23	1.63	2.99	3.62	0.60	1.50	13.56	3.33	0.86	0.41	0.14	0.22	0.35
12	0.91	0.83	1.57	1.19	0.41	0.20	0.59	1.09	0.47	2.70	5.47	0.37	0.70	4.89	2.21	0.15	0.08	0.00	0.15
13+	2.11	0.61	0.40	1.44	0.64	0.68	0.82	0.74	0.81	1.94	2.33	0.21	0.12	0.28	3.54	1.65	0.83	0.42	0.27

Table 7. Mean weights at age (kg) for 4X haddock stock derived from commercial statistics

AGE	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	.56	.27	.18	.23	.23	.28	(.29)	(0.29)	0.23
2	.56	.50	.50	.36	.31	.32	.37	.56	.57	.50	.45	.51	.46	.52	.52	.46	.44	0.51	0.54
3	.75	.78	.75	.65	.67	.62	.62	.75	.90	.96	.90	.75	.82	.82	.81	.71	.87	0.87	0.90
4	1.15	1.05	1.00	1.00	.85	.85	.9	.88	1.05	1.25	1.35	1.25	1.10	1.20	1.19	1.22	1.33	1.33	1.32
5	1.40	1.45	1.30	1.20	1.23	1.05	1.10	1.15	1.16	1.40	1.60	1.80	1.70	1.55	1.60	1.72	1.85	1.84	1.75
6	1.60	1.70	1.70	1.56	1.50	1.45	1.30	1.35	1.43	1.50	1.75	2.00	2.30	2.25	2.10	2.20	2.33	2.36	2.35
7	2.20	1.85	1.95	1.95	1.80	1.80	1.70	1.60	1.65	1.75	1.90	2.20	2.50	2.85	2.95	2.94	2.67	2.83	2.86
8	2.12	2.35	2.04	2.20	2.18	2.05	2.05	2.00	1.95	1.95	2.10	2.30	2.60	3.00	3.50	3.30	3.39	3.30	3.31
9	1.90	2.25	2.50	2.30	2.50	2.36	2.30	2.45	2.30	2.30	2.30	2.50	2.80	3.20	3.60	3.57	3.77	4.03	3.69
10	2.40	2.20	2.40	2.63	2.50	2.70	2.52	2.50	2.82	2.65	2.80	2.70	2.95	3.80	3.80	3.77	4.17	4.15	4.13
11	2.86	2.70	2.42	2.50	2.75	2.70	3.00	2.70	2.80	3.25	3.00	3.30	3.20	3.50	4.10	3.69	4.03	4.96	4.17
12	2.70	3.20	3.00	2.70	2.60	2.89	2.90	3.30	2.85	3.00	3.70	3.40	3.80	3.70	4.00	3.94	3.62	6.00	4.78
13+	3.99	3.25	3.61	3.30	3.00	2.80	2.95	3.06	3.60	3.00	3.20	4.20	3.90	4.40	4.20	3.91	4.63	5.68	4.83

Weights in parenthesis are estimates, based on 1972-1978 data.

Table 8. Indices of abundance for the 4X haddock stock

	RESEARCH SURVEYS				COMMERCIAL STATISTICS			
	Canadian Summer Strata 70-91,95 (smoothed over 3 years)		U.S. Fall Strata 31-34 (smoothed over 3 years)		Canadian Otter Trawlers (mt/hr) (>50% of catch) Tonnage Class 3		Tonnage Class 4	U.S. Otter Trawlers Tonnage Class 4
Year	num/tow	kg/tow	num/tow	kg/tow	side	stern	side & stern	(mt/hr)
1963			191.92	67.91				0.271
1964			52.07	31.82				0.313
1965			52.07	31.82				0.271
1966			52.07	34.91				0.196
1967			51.63	34.91				0.225
1968			30.92	28.53			0.285	0.188
1969			23.74	17.66			0.204	0.142
1970	21.385	22.95	23.74	17.66	0.079	0.058	0.170	0.133
1971	21.385	22.95	39.01	24.1	0.114	0.085	0.170	0.104
1972	25.484	13.24	39.01	24.1	-	0.214	0.168	0.138
1973	30.21	13.24	25.48	20.74	0.200	0.124	0.149	0.104
1974	30.21	21.29	24.78	20.74	0.542	0.192	0.165	-
1975	24.409	22.21	24.78	20.74	0.215	0.253	0.243	0.242
1976	24.409	22.21	38.69	21.94	-	0.323	0.310	0.217
1977	27.746	26.46	54.18	53.59	0.255	0.391	0.286	0.321
1978	37.581	41.98	86.30	53.59	0.500	0.470	0.386	(1)
1979	37.581	41.98	87.99	53.59	0.226	0.306	0.488	(1)
1980	61.679	57.01	87.99	33.47	0.276	0.388	0.420	(1)

[1] Not calculated due to 10% trip limitation on U.S. vessels

Table 9. Stratified mean catch (in numbers) per standard tow of haddock caught during U.S. Fall Bottom Trawl Survey (Strata 31-42)

AGE	1963*	1964*	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976*	1977	1978*	1979*	1980*
0	79.39	0.21	0.44	0.70	0.08	2.05	10.22	0.10	12.59	8.19	1.82	4.10	9.58	11.71	12.06	6.08	25.24	55.57
1	48.68	14.21	6.07	1.18	3.37	0.91	4.13	4.31	0.02	20.59	8.89	1.79	6.93	13.66	8.98	9.85	12.05	42.83
2	15.67	10.96	26.10	1.51	1.25	2.64	0.77	2.14	5.76	0.18	12.31	5.26	3.42	4.43	18.13	11.93	28.85	8.73
3	14.03	3.58	9.87	22.31	2.44	1.09	2.16	0.67	1.60	4.31	0.16	5.39	4.51	1.92	9.63	14.45	8.47	5.52
4	19.62	4.62	3.55	7.42	22.09	0.37	0.31	1.27	0.67	1.26	3.48	0.14	5.38	2.38	2.44	5.61	8.38	2.37
5	7.64	7.37	3.18	2.23	4.04	8.41	0.08	0.20	0.98	0.32	0.83	1.54	0	3.66	3.49	2.43	2.84	1.95
6	3.29	2.18	4.13	1.57	0.92	2.97	2.91	0.71	0.19	0.54	0.11	0.47	0.74	0	3.82	3.14	1.52	0.47
7	1.52	0.63	1.25	2.28	0.83	0.33	1.22	2.43	0.11	0.14	0.35	0.05	0.29	0.58	0.19	0.43	0.60	0.19
8	1.21	0.75	0.30	0.84	0.40	0.42	0.13	0.81	2.51	0.07	0.12	0.28	0.18	0.02	0.12	0	0.04	0.35
9	0.33	0.34	0.40	0.55	0.14	0.52	0.33	0.25	0.83	1.17	0.24	0.03	0.07	0	0.14	0.12	0	0.11
10	0.42	0	0	0	0	0	0.19	0.15	0.19	0.22	0.83	0.04	0.02	0.02	0	0.07	0	0
11	0.05	0	0	0	0	0	0.05	0.14	0.23	0.04	0.08	1.09	0.05	. 0	0.05	0	0	0
12	0.08	0	0	0	0	0	0	0.04	0	0.08	0	0.18	0.03	0.25	0.02	0	0	0
13	0	0	0	0	0	0	0	0.02	0	0.01	0	0	0.07	0.03	0.02	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0.12	0.01	0	0.04	0.05	0	0
TOTAL	191.92	44.85	55.29	40.61	35.56	19.71	22.50	13.26	25.69	37.12	29.24	20.47	31.28	38.66	59.14	54.18	87.99	118.09
Ages 2+	63.86	30.43	48.78	38.71	32.11	16.75	8.15	8.83	13.07	8.34	18.51	14.59	14.77	13.29	38.09	38.23	50.70	19.69
Ages 5+	14.54	11.27	9.26	7.47	6.33	12.65	4.91	4.75	5.04	2.59	2.55	3.80	1.46	4.56	7.89	6.24	5.00	3.07
Total Kg/tow	67.91	31.43	30.59	33.49	27.11	19.10	12.79	14.53	17.05	17.10	18.94	17.21	18.29	21.94	48.73	53.59	55.55	33.47

* Strata 41 and 42 not sampled.

Table 10. Stratified mean catch (in numbers) per standard tow of haddock caught during U.S. Fall Bottom Trawl Survey (Strata 31-34)

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	79.39	0.21	1.53	1.12	0.13	3.55	10.27	0.13	20.46	7.74	1.12	3.70	7.10	11.71	12.55	6.08	25.24	55.57
1	48.68	14.21	2.46	1.83	6.29	1.72	4.66	4.88	0.06	34.03	3.85	2.77	4.42	13.66	16.16	9.85	12.05	42.83
2	15.67	10.96	24.99	2.88	2.44	4.60	0.52	2.51	8.61	0.12	16.12	6.72	2.91	4.43	29.46	11.93	28.85	8.73
3	14.03	3.58	10.67	39.85	3.89	1.62	2.17	0.41	2.30	5.32	0.16	7.54	1.96	1.92	13.33	14.45	8.47	5.52
4	19.62	4.62	3.67	12.82	31.64	0.49	0.32	1.16	0.31	1.54	1.95		5.07	2.38	3.99	5.61	8.38	2.37
5	7.64	7.37	2.95	4.08	4.57	12.83	0.04	0.25	1.07	0.18	0.35	0.87	_	3.66	4.27	2.43	2.84	1.95
6	3.29	2.18	3.99	2.30	0.98	4.13	3.09	0.81	0.16	0.60	0.16	0.36	0.35	_	6.02	3.14	1.52	0.47
7	1.52	0.63	1.24	3.80	1.07	0.53	1.42	3.09	0.11	0.17	0.16	0.13	0.23	0.58	0.14	0.43	0.60	0.19
8	1.21	0.75	0.19	1.55	0.47	0.73	0.17	1.29	3.70	0.14	0.08	0.14	0.14	0.02	0.09	_	0.04	0.35
9	0.33	0.34	0.37	0.90	0.17	0.71	0.62	0.34	1.54	1.83	0.30	0.07	0.12	_	0.10	0.12	_	0.11
10	0.42	_	_	_	_	_	0.36	0.34	0.28	0.36	1.07	0.07	_	0.02	_	0.07	_	_
11	0.05	_	_	_	_	_	0.10	0.16	0.41	_	0.12	2.02	0.03	_	0.09	_	_	_
12	0.08	_	_	_	_	_	_	0.06	_	0.20	_	0.27	0.05	0.25	_	_	_	_
13	_	_	_	_	_	_	_	0.05	_	_	_	_	0.04	0.03	_	_	_	_
14	_	_	_	_	_	_	_	_	_	_	_	0.12	_	_	0.10	0.05	_	_
TOTAL	191.92	44.85	52.07	71.15	51.63	30.92	23.74	15.48	39.01	52.22	25.44	24.78	22.42	38.66	86.30	54.18	87.99	118.09
AGES 2+	63.86	30.43	48.07	68.18	45.23	25.64	8.81	10.47	18.49	10.46	20.47	18.31	10.90	13.29	57.59	38.23	50.70	19.69
AGES 5+	14.54	11.27	8.74	12.63	7.26	18.93	5.80	6.39	7.27	3.48	2.24	4.05	0.96	4.56	10.81	6.24	5.00	3.07
TOTAL kg/tow	67.91	31.43	31.82	58.65	34.91	28.53	14.59	17.66	24.10	24.45	17.27	20.74	13.86	21.94	75.29	53.59	55.55	33.47

Table 11. Stratified mean catch (in numbers) per standard tow of haddock caught during Canadian Summer Bottom Trawl Survey (strata 70-91, 95).

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	-	-	-	-	-	-	-	0.007	-	0.352	0.024
1	4.872	0.099	4.404	4.976	8.153	5.518	4.617	5.278	5.391	1.636	18.511
2	3.921	9.263	0.195	19.053	17.942	3.466	5.272	20.246	4.660	11.528	6.028
3	1.148	3.933	2.732	0.479	21.220	4.383	3.394	13.077	9.544	6.605	13.179
4	2.167	1.729	1.160	2.466	0.768	6.013	3.405	3.868	2.870	7.919	6.841
5	0.881	2.489	0.761	1.131	3.578	0.394	6.175	5.557	1.400	4.009	10.472
6	1.982	1.131	0.825	0.423	0.775	1.417	0.467	3.456	2.615	1.605	3.527
7	5.073	1.746	0.543	0.569	0.438	0.510	0.553	0.466	0.988	2.524	1.298
8	0.704	4.424	0.808	0.429	0.505	0.287	0.101	0.558	0.025	0.949	1.056
9	0.293	0.504	1.106	0.287	0.268	0.136	0.026	0.121	-	0.208	0.510
10	0.258	0.078	0.037	0.371	0.202	0.043	0.033	0.095	-	0.026	0.202
11	0.069	0.035	0.005	0.018	0.287	0.246	0.008	0.008	0.035	-	0.031
12	0.017	0.053	0.004	0.008	-	0.153	0.284	0.216	0.130	0.099	-
NK	-	-	0.066	-	-	-	0.074	0.007	0.088	0.121	-
TOTAL	21.385	25.484	12.646	30.210	54.136	22.566	24.409	52.960	27.746	37.581	61.679
2+	16.513	25.385	8.242	25.234	45.983	17.048	19.792	47.675	22.355	35.593	43.144
5+	9.277	10.460	4.155	3.236	6.053	3.186	7.721	10.484	5.281	9.541	17.096
TOTAL kg/tow	22.95	27.50	13.24	12.77	39.46	21.29	22.21	90.45	26.46	41.98	57.01

Table 12. Strata ranking of haddock catches (numbers per tow) from Canadian Summer Bottom Trawl Survey

1 - highest catch rate; 2 - second highest catch rate . . . . 5 - fifth highest catch rate.

O - Strata equivalent sampled by U.S. Fall Bottom Trawl Survey

STRATA	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
70								2			
71											
72						4					2
73	2		2	4			2	3		5	
(74)	5		4		4	2	4		2	2	
75	3	4		5	3		1		4		5
(76)		2			5	3					
77		5	5				5				
78											
79											
(80)	1	1	1	2	2	1		1	1	3	3
(81)	4		3	1	1				3	4	4
82											
83											
84											
(85)											
90		3		3		5	3	5	5	1	1
91								4			
92											
93											
94											
95											

Table 13. Analysis of variation present in Canadian Summer Bottom Trawl Survey

Year	Strata Contributing Most to Survey Estimate	% Contribution to Abundance Estimate	% Contribution to Overall Variance	No. Sets
1970	81	26.7	30.1	5
	85	18.6	54.0	2
		45.3	84.1	7
1971	76	23.69	50.9	2
	80	31.47	25.5	4
		55.16	76.4	6
1972	80	26.09	45.98	4
	81	23.72	38.31	4
		49.81	84.29	8
1973	81	56.27	84.31	4
1974	81	40.87	61.35	4
	90	15.41	22.08	2
		56.28	83.43	6
1975	72	13.74	39.00	2
	76	17.73	>1	6
	80	26.15	14.57	3
	81	16.84	38.15	4
		74.46	91.72	15
1976	77	19.20	34.87	2
	81	24.64	7.77	4
	90	15.22	11.43	3
		59.06	54.07	9
1977	76	45.75	84.66	4 (one tow primarily)
1978	80	24.34	35.97	3
	81	31.35	62.48	4
		55.69	98.45	7
1979	81	21.22	71.63	4
	90	30.32	6.57	2
		51.54	78.20	6
1980	72	25.93	43.85	2
	81	25.93	41.42	3
		51.86	85.27	5

Table 14. Summary of survivor output parameters in analysis of Canadian Summer Bottom Trawl Survey Data

Ages in Data Set	Calibration Block Final Year	Calibration Block Oldest Age	Age of Full Recruitment	K Age 6	Residuals $\bar{X}$	Residuals 50	Range (%) of CV's for Last Year for ages 3-8	No. Outliers	Estimated Survivors (Weighted) 3	4	5	6	7	8
1-9	1974	5	5	13775	0.454	0.722	99-220	3	63765	23548	27664	5496	6888	5532
2-9	1975	6	5	3226	0.239	0.552	65-142	2	50827	16192	17676	2712	2127	2474
2-9	1976	6	6	5207	0.302	0.596	63-139	3	53829	18084	21189	3220	2156	3460
2-9	1977	6	6	4694	0.274	0.590	58-136	3	48267	16025	18875	2716	1882	3091
2-9	1978	6	6	5018	0.294	0.586	58-122	3	51683	17500	21383	3378	2324	3502
2-9	1979	6	6	4531	0.280	0.576	54-114	3	50907	17271	20778	3306	2147	3293
3-9	1979	6	6	2829	0.211	0.508	50-86	1	49549	19390	16848	3130	1611	2184
3-9	1979	7	6	1909	0.142	0.486	49-86	3	47169	18259	15430	2610	1179	1420
3-9	1979	8	6	1789	0.128	0.485	50-89	3	46840	18112	15248	2514	1110	1805
3-9	1980	6	6	2533	0.189	0.501	47-60	2	48548	18826	16061	2881	1421	1942
3-8	1979	7	6	2257	0.116	0.361	49-84	2	48009	18985	16314	2925	1403	1750*
3-8	1979	8	8	2663	0.151	0.392	52-84	2	52545	20713	18429	3480	1803	2534

* Run chosen to determine F_R in 1980

Table 15. Results of survivor method including analysis of variance.

INTEGRATED CATCH 5/ 5/81

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	3957	6596	12085	3130	22560	21761	9705	22334	17923	4625	1416
4	5188	2553	3828	7346	2367	14010	13822	6277	13602	10038	1726
5	1416	2924	1509	1834	4201	1574	7495	7963	3274	6270	2798
6	445	804	1475	765	800	2149	873	3180	3797	1270	1818
7	6442	106	441	645	310	318	900	357	869	1298	304
8	980	1744	30	169	141	90	81	205	72	138	277

FINAL ITERATION (1)

INTEGRATED SURVIVORS 5/ 5/81

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	1078	550	1718	9	4690	5254	3451	5888	26892	25623	53936
4	1498	883	450	1407	7	3839	4302	2825	4821	22018	20978
5	1307	1226	723	369	1152	6	3143	3522	2313	3947	18026
6	3344	1070	1004	592	302	943	5	2574	2884	1894	3232
7	7376	2738	876	822	485	247	772	4	2107	2361	1551
8	609	6039	2241	717	673	397	202	632	3	1725	1933

POPULATION NUMBERS 5/ 5/8

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	5035	7146	13803	3139	27249	27015	13156	28222	44815	30249	55351
4	6686	3436	4278	8753	2374	17849	18124	9103	18423	32055	22705
5	2723	4151	2232	2203	5353	1580	10638	11485	5587	10217	20025
6	3789	1874	2479	1357	1102	3092	878	5754	6681	3164	5049
7	13818	2844	1317	1467	794	565	1672	361	2976	3659	1854
8	1589	7782	2271	987	815	487	283	837	75	1863	2210

ESTIMATED SURVIVORS 5/ 5/81

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	288	3304	0	0	22161	0	1850	16186	13444	17127	48809
4	1123	1541	174	692	183	3274	0	3930	0	14089	21150
5	418	1715	219	529	2466	0	4135	3116	190	7964	21746
6	2443	1061	235	115	576	637	110	2802	1277	1743	5559
7	3710	2841	581	474	503	617	258	515	1009	3259	2376
8	551	7458	1623	723	903	504	133	955	0	1813	1906

ESTIMATED VARIANCE OF SURVIVORS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	980295	11505907	5551807	170665	334937467	14289463	12782460	983090180	2249506629	1607277351	9111220467
4	3976078	2531204	1139339	5149004	499413	30613960	9816832	18898522	15521600	176291418	1873[illegible]848
5	478069	3815829	356704	787888	7885328	95616	23486213	19020410	1800997	22031637	2140[illegible]314
6	2801417	912212	485376	127600	428325	1431892	155526	8517415	4876564	2740554	1884[illegible]
7	26134527	3095804	299423	328783	194820	264135	310553	220524	991296	6469394	[illegible]
8	750841	29650563	989066	278816	386354	124786	15454	471706	947	1764379	[illegible]

WEIGHTED SURVIVORS 5/ 5/81

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	12	4	0	0	34	0	100	344	4041	9218	48809
4	34	24	2	21	0	55	0	144	0	5404	9766
5	86	55	24	9	48	0	91	139	73	809	6869
6	516	115	59	36	18	68	1	170	223	441	1772
7	1972	543	192	176	102	32	127	2	525	428	645
8	351	3494	970	256	285	160	118	309	0	686	960

RMS=0.3458871348

Table 15. continued

ESTIMATED SURVIVORS FOR AGE 3 (WEIGHTED)

YEAR	SURVIVORS	VARIANCE	STANDARD ERROR	C.V.(%)
1970	551	750841	867	157.15
1971	5466	13890870	3727	68.19
1972	2029	591354	769	37.90
1973	650	98870	314	48.40
1974	609	121897	349	57.34
1975	359	39679	199	55.53
1976	183	13687	117	63.80
1977	573	152915	391	68.28
1978	3	921	30	967.11
1979	1561	516167	718	46.02
1980	1750	850349	922	52.69

ESTIMATED SURVIVORS FOR 1980 (WEIGHTED)

AGE	SURVIVORS	VARIANCE	STANDARD ERROR	C.V.(%)
3	48809	911220467	30186	61.85
4	18985	86509395	9301	48.99
5	16314	67616474	8223	50.40
6	2925	6009240	2451	83.82
7	1403	692967	832	59.32
8	1750	850349	922	52.69

FINAL ESTIMATION FOR X

AGE	X	LN(X)	VAR(LN(X))	STANDARD ERROR	D.F
3	4200.46	8.1914	0.3031	0.1741	1
4	3669.19	8.1465	0.1225	0.1107	1
5	2562.19	7.7841	0.1291	0.1136	1
6	2257.19	7.5905	0.2627	0.1146	19
7	2257.19	7.5905	0.2627	0.1146	19
8	2257.19	7.5905	0.2627	0.1146	19

RESIDUALS 5/ 5/81

I	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	-0.0433	0.8381	-0.1847	-0.4447	1.1851	-0.3835	0.0803	0.6659	-0.1114	-0.0864	0.0001
4	0.1733	0.6132	-0.0052	0.0331	0.1713	0.2119	-0.3720	0.4441	-0.5593	-0.0982	0.1003
5	-0.1875	0.4294	-0.1350	0.2744	0.5381	-0.1480	0.3969	0.2149	-0.4431	0.0053	0.2534
6	0.1662	0.3093	-0.2862	-0.3517	0.4624	0.0339	0.1824	0.3043	-0.1239	0.1355	0.4553
7	-0.1879	0.3264	-0.0721	-0.1329	0.2187	0.7111	-0.2925	1.0695	-0.2885	0.4429	0.4573
8	0.0003	0.2493	-0.2194	0.0882	0.3361	0.2849	-0.2170	0.4090	-0.2892	0.1393	0.0758

MEAN OF RESIDUALS=0.1157565714
STANDARD DEVIATION OF RESIDUALS=0.3616113332

OUTLIERS OF RESIDUALS 5/ 5/81

I	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 15. continued

ANALYSIS OF VARIANCE

SOURCE		B	STAND ERROR OF B
CONSTANT		0.114	
AGE	4	-0.089	0.118
	5	-0.066	0.126
	6	-0.002	0.135
	7	0.136	0.145
	8	0.026	0.145
YEAR	1971	0.391	0.160
	1972	-0.292	0.161
	1973	-0.259	0.165
	1974	0.249	0.169
	1975	-0.178	0.174
	1976	-0.315	0.180
	1977	0.257	0.187
	1978	-0.588	0.194
	1979	-0.185	0.184
	1980	0.005	0.174
YRCLASS	1963	-0.360	0.254
	1964	-0.109	0.227
	1965	-0.063	0.208
	1966	-0.029	0.193
	1967	-0.002	0.176
	1968	0.297	0.185
	1969	0.064	0.184
	1970	0.065	0.183
	1971	0.337	0.181
	1972	0.028	0.176
	1973	0.190	0.187
	1974	0.195	0.201
	1975	0.208	0.219

SUMMARY OF ANALYSIS OF VARIANCE

SOURCE	SS	DF	MS	F
CONSTANT	0.8578	1		
AGE	0.28291	5	0.0566	0.752
YEAR	4.46136	10	0.4461	5.929
YRCLASS	0.89580	14	0.0640	0.850
RESIDUALS	2.85930	36	0.0794	
TOTAL	9.35715	66		

Table 16. Conort analysis results for option 1 (recruitment as determined by survivor method).

POPULATION NUMBERS

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	24977	91674	201143	16783	10116	17407	8071	14727	25405	6467	48456	16905	25873	50577	78201	50793	92695
2	36913	20450	75057	164682	13741	8292	14251	6608	12057	20800	5294	39635	38185	21182	41376	64009	41584
3	30485	30096	16098	61311	134767	11052	6761	11066	5401	9917	16316	4315	29666	30635	15375	32703	51244
4	19235	45427	22819	12029	47448	93742	8582	5267	7236	3767	5838	10251	3430	20079	20949	11100	23946
5	11654	14468	30691	14805	8056	29983	58309	5973	3531	4565	2371	3114	6360	2529	11766	13296	7261
6	9657	7933	9052	16679	9268	3730	16271	31952	3424	1730	2451	1481	1584	3597	1632	6302	7996
7	4703	6361	5003	4681	8762	5644	2114	9083	15987	2329	1050	1423	736	836	1947	943	2553
8	3207	2359	3928	2746	2047	3783	3955	1085	4523	8985	1844	779	622	431	461	864	446
9	1959	1745	1395	1976	1343	916	2145	2770	477	2018	4356	1459	346	266	197	238	355
10	1104	1021	996	588	944	730	581	1148	2042	270	729	2511	960	115	162	97	98
11	526	694	698	439	221	389	505	303	765	1585	74	133	1500	542	65	47	15
12	217	245	466	303	176	101	237	295	93	468	1134	37	60	729	295	18	17
	174637	222473	367346	297021	236888	175759	121784	90279	79941	61900	89914	111942	109322	131519	172425	180410	228211

	1979	1980
1	45389	132406
2	75892	37162
3	33978	62062
4	38920	26771
5	13259	25794
6	4050	7344
7	3984	2348
8	1149	2137
9	242	703
10	194	146
11	57	97
12	4	37
	217119	297007

FISHING MORTALITY 3/ 5/81

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.000
2	0.004	0.039	0.002	0.000	0.018	0.003	0.053	0.002	0.102	0.043	0.005	0.090	0.020	0.120	0.035	0.022	0.002	0.001	0.005
3	0.086	0.077	0.091	0.056	0.163	0.053	0.050	0.225	0.160	0.224	0.265	0.029	0.190	0.180	0.126	0.112	0.075	0.038	0.049
4	0.085	0.192	0.233	0.201	0.259	0.275	0.162	0.533	0.261	0.263	0.429	0.277	0.105	0.334	0.255	0.224	0.391	0.211	0.145
5	0.185	0.269	0.410	0.268	0.570	0.411	0.402	0.357	0.181	0.422	0.271	0.476	0.370	0.239	0.424	0.308	0.384	0.391	0.257
6	0.217	0.261	0.460	0.444	0.296	0.368	0.383	0.492	0.185	0.299	0.344	0.500	0.439	0.414	0.348	0.704	0.497	0.345	0.720
7	0.490	0.282	0.400	0.627	0.640	0.155	0.467	0.497	0.376	0.033	0.099	0.627	0.334	0.395	0.613	0.548	0.598	0.423	0.315
8	0.408	0.325	0.487	0.515	0.604	0.367	0.156	0.622	0.607	0.524	0.035	0.611	0.649	0.581	0.461	0.688	0.414	0.292	0.315
9	0.452	0.361	0.663	0.539	0.410	0.256	0.425	0.105	0.368	0.818	0.351	0.218	0.901	0.298	0.507	0.686	0.404	0.302	0.315
10	0.264	0.180	0.619	0.779	0.686	0.168	0.449	0.207	0.053	1.099	1.497	0.315	0.371	0.367	1.047	1.698	0.347	0.489	0.315
11	0.564	0.198	0.635	0.715	0.580	0.295	0.338	0.985	0.292	0.135	0.494	0.608	0.522	0.410	1.080	0.791	1.145	0.241	0.315
12	0.392	0.307	0.502	0.531	0.487	0.286	0.358	0.429	0.384	0.419	0.207	0.489	0.581	0.422	0.482	0.657	0.478	0.341	0.315
	0.094	0.096	0.081	0.080	0.211	0.244	0.289	0.325	0.180	0.217	0.127	0.103	0.109	0.138	0.094	0.098	0.096	0.085	0.070

NUMBER OF ITERATIONS : 4

Table 17. Summary of correlation coefficients obtained with various terminal F's in 1980* for Option 2.

F	2 To 5 SPA vs 2 To 5 Research	6+ SPA vs 6+ Research	2+3 SPA vs 2+3 Research	3+ SPA Biomass vs Commercial CPUE
0.2	0.68	0.84	0.85	0.94
0.25	0.65	0.88	0.85	0.94
0.3	0.62	0.89	0.85	0.93
0.315	0.61	0.89	0.84	0.93
0.325	0.6	0.89	0.84	0.92
0.35	0.58	0.88	0.84	0.91
0.4	0.55	0.87	0.84	0.88
0.5	0.47	0.83	0.8	0.78

* Partial recruitment for all runs was:

Age	1	2	3	4	5	6	7+
PR	.001	0.2	0.4	0.6	0.8	1	1

Table 18. Final cohort analysis results for option 2 (standard assessment procedure)

POPULATION NUMBERS

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	24977	91675	201160	16796	10118	17410	8072	14741	25436	6504	48605	47176	26207	70419	81785
2	36919	20450	75057	164696	13752	8284	14254	6609	12069	20825	5325	39757	38488	21455	57621
3	60485	30101	16096	61311	134778	11061	6762	11068	5402	8926	16337	4340	29766	30884	15598
4	19235	45429	22823	12029	47449	93751	8590	5268	7238	3768	5845	10268	3451	20160	21152
5	11459	14468	30692	14808	8056	29984	58317	5980	2532	4567	2372	3120	6374	7546	11833
6	6857	7933	9052	16680	9271	3730	16271	31958	3429	1730	2452	1481	1589	3609	1646
7	4203	4361	5003	4681	8762	5646	2114	9083	15992	2333	1051	1424	736	840	1957
8	2307	2559	3928	2746	2047	3763	3957	1085	4523	8989	1848	779	623	431	464
9	1466	1745	1395	1976	1343	916	2146	2771	477	2018	4359	1461	346	267	198
10	1104	1021	996	586	944	730	581	1149	2044	270	729	2514	962	115	162
11	826	694	698	437	221	389	505	303	765	1586	74	134	1502	544	65
12	619	245	466	303	176	101	237	295	93	468	1135	37	60	731	296
1+	174644	222480	367368	297053	236916	175785	121806	90311	79999	61984	90132	112491	110105	152002	192778

	1977	1978	1979	1980
1	41959	76120	45299	44140
2	86944	34352	62322	37088
3	46003	53646	28057	50952
4	11283	34836	40887	21923
5	13462	7411	22174	27405
6	6357	8133	4173	14643
7	955	2598	4096	2448
8	872	456	1186	2228
9	241	362	249	733
10	98	100	199	152
11	47	15	59	102
12	18	18	4	38
1+	188239	218046	206705	201852

FISHING MORTALITY

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.000	0.001	0.000	0.000
2	0.004	0.039	0.002	0.000	0.018	0.003	0.053	0.002	0.102	0.043	0.005	0.089	0.020	0.119	0.025	0.021
3	0.086	0.077	0.091	0.056	0.163	0.053	0.050	0.225	0.160	0.223	0.264	0.029	0.190	0.178	0.124	0.078
4	0.085	0.192	0.233	0.201	0.259	0.275	0.162	0.533	0.261	0.263	0.428	0.277	0.104	0.333	0.252	0.220
5	0.185	0.269	0.410	0.268	0.570	0.411	0.401	0.356	0.181	0.422	0.271	0.475	0.369	0.236	0.421	0.304
6	0.217	0.261	0.460	0.444	0.296	0.368	0.383	0.492	0.185	0.298	0.343	0.500	0.437	0.412	0.345	0.695
7	0.490	0.282	0.400	0.627	0.640	0.155	0.466	0.497	0.376	0.033	0.099	0.627	0.334	0.393	0.609	0.539
8	0.408	0.325	0.487	0.515	0.604	0.367	0.156	0.622	0.607	0.524	0.035	0.610	0.648	0.581	0.456	0.680
9	0.452	0.361	0.663	0.539	0.410	0.256	0.425	0.105	0.368	0.818	0.350	0.218	0.900	0.297	0.506	0.675
10	0.264	0.180	0.619	0.779	0.686	0.168	0.449	0.207	0.053	1.099	1.497	0.315	0.370	0.366	1.041	1.691
11	0.564	0.198	0.635	0.715	0.580	0.295	0.338	0.985	0.291	0.135	0.494	0.607	0.521	0.408	1.073	0.781
12	0.392	0.307	0.502	0.531	0.487	0.286	0.357	0.429	0.384	0.418	0.207	0.489	0.580	0.421	0.479	0.647
1+	0.094	0.096	0.081	0.080	0.211	0.244	0.289	0.325	0.180	0.217	0.127	0.102	0.109	0.119	0.084	0.093

	1978	1979	1980
1	0.000	0.000	0.000
2	0.002	0.001	0.005
3	0.072	0.047	0.060
4	0.252	0.200	0.180
5	0.374	0.215	0.240
6	0.486	0.333	0.300
7	0.584	0.409	0.300
8	0.404	0.281	0.300
9	0.396	0.291	0.300
10	0.337	0.473	0.300
11	1.125	0.232	0.300
12	0.467	0.329	0.300
1+	0.098	0.086	0.099

NUMBER OF ITERATIONS : 4

Table 19. Comparison of numbers (x 10^{-3}) at age 1 generated by CAFSAC Assessments since 1976.

ASSESSMENT	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	F_R
O'BOYLE unpublished assessment #1 1977	30810	7007	60391	49293	28861	33393	-	-	-	-	-	0.28
O'BOYLE unpublished assessment #2 1977	20810	7007	60231	35308	14606	26889	44755	-	-	-	-	0.33
Res. Doc. 78/19	33077	10775	75014	56364	34737	43539	81036	29423	-	-	-	0.3
Res. Doc. 80/2	26436	7169	50301	53352	28948	56167	73480	41293	50339	-	-	0.325
Present Doc.												
Opt. 1	25405	6467	48456	46805	25873	50577	78201	50793	92695	45389	-	0.315
Opt. 2	25436	6504	48605	47176	26207	70419	81785	41959	76120	45299	-	0.300
FINAL	25436	6504	48605	47176	26207	50577	81785	41959	76120	45299	100000	0.300

Table 20. Final cohort analysis for present assessment.

POPULATION NUMBERS

I	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	24977	21678	201156	11706	10118	17410	8372	11741	11436	1504	43805	97111	11[illegible]	[illegible]	[illegible]
2	36919	17450	14667[illegible]	114[illegible]	[illegible]	8264	14564	8609	11469	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	20487	30101	14668	11111	13477[illegible]	11260	[illegible]	11038	14[illegible]	3926	[illegible]	1340	14736	[illegible]	[illegible]
4	[illegible]	15439	[illegible]	[illegible]	47448	11739	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	14468	[illegible]	14809	2056	10094	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

I	1977	1978	1979	1980
1	[illegible]	[illegible]	[illegible]	44140
2	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]
1+	[illegible]	[illegible]	[illegible]	[illegible]
2+	[illegible]	[illegible]	[illegible]	[illegible]
3+	[illegible]	[illegible]	[illegible]	[illegible]
4+	[illegible]	[illegible]	[illegible]	[illegible]

FISHING MORTALITY

I	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.004	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	0.096	0.077	0.091	0.000	0.000	0.000	0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	0.239	0.239	0.410	[illegible]	[illegible]	0.401	0.401	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	0.490	[illegible]	0.490	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	0.408	[illegible]	0.467	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	0.467	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9+	0.240	0.278	0.478	0.000	0.482	0.271	0.289	0.469	0.264	0.440	0.000	0.424	0.486	0.416	0.000	0.000

I	1978	1979	1980
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
9+	[illegible]	[illegible]	[illegible]

Table 21. Comparison of partial recruitment, weight (kg) at age and yield per recruit estimates for 4X haddock at differing stock sizes.

Age	Weight (kg) at age Mean of 1962-1980 Commercial Sample Data	Partial Recruitment at High Stock Size (1962-64)	Partial Recruitment at Low Stock Size (1971-73)	1980 Partial Recruitment
1	0.287	0.001	0.003	0.0003
2	0.472	0.050	0.103	0.017
3	0.784	0.230	0.614	0.20
4	1.119	0.470	1	0.60
5	1.466	0.700	1	0.80
6	1.828	0.900	1	1
7	2.209	1	1	1
8	2.510	1	1	1
9	2.769	1	1	1
10	3.013	1	1	1
11	3.244	1	1	1
12	3.478	1	1	1
$F_{0.1}$		0.313	0.256	0.304
F_{MAX}		0.721	0.519	0.734
Yield (kg) at $F_{0.1}$		0.510	0.495	0.515

Table 22. Yield per recruitment calculations and 1980 population parameters used in the catch projection.

AGE	MEAN (1978-80) WEIGHT AT AGE kg.	1980 CATCH AT AGE NUMBER X 10^{-3}	1980 POPULATION AT AGE NUMBER X 10^{-3}	PARTIAL RECRUITMENT
1	0.269	12	100000	0.0003
2	0.489	168	37088	0.0167
3	0.878	2692	50952	0.2
4	1.325	3283	21924	0.6
5	1.816	5321	27405	0.8
6	2.345	3457	7344	1
7	2.797	578	2449	1
8	3.332	526	2229	1
9	3.829	173	733	1
10	4.151	36	153	1
11	4.386	24	102	1
12	4.798	9	39	1

$F_{0.1}$	0.284
F_{max}	0.595
Yield at $F_{0.1}$, kg.	0.639
M	0.2

Table 23. Catch projection at $F_{0.1}$ to 1982 under the 1980 conditions as outlined in Table 22. A value of 40 x 10^6 was taken for age 1 recruitment for 1981 and 1982.

Year	1+ Population Number x10^{-6}	Mean 1+ Population Biomass, mt x10^{-3}	1+ Catch Biomass, mt x10^{-3}	1+ Surplus Production, mt x10^{-3}
1980	250	171	29	56
1981	230	185	28	41
1982	214	196	32	38

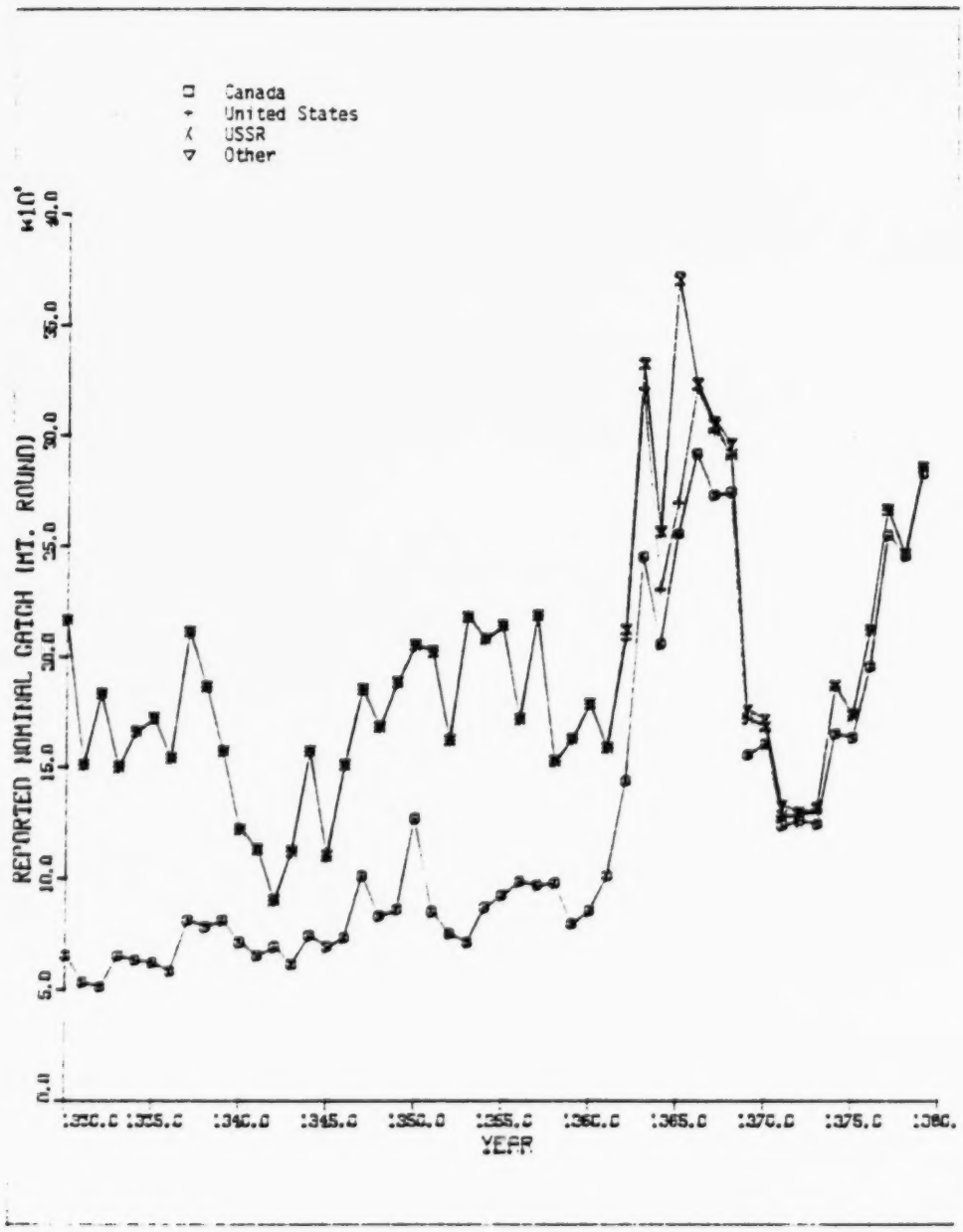


Figure 1. Reported nominal catches (mt round) of haddock from NAFO Division 4X (excluding unit area 4Xs) by country.

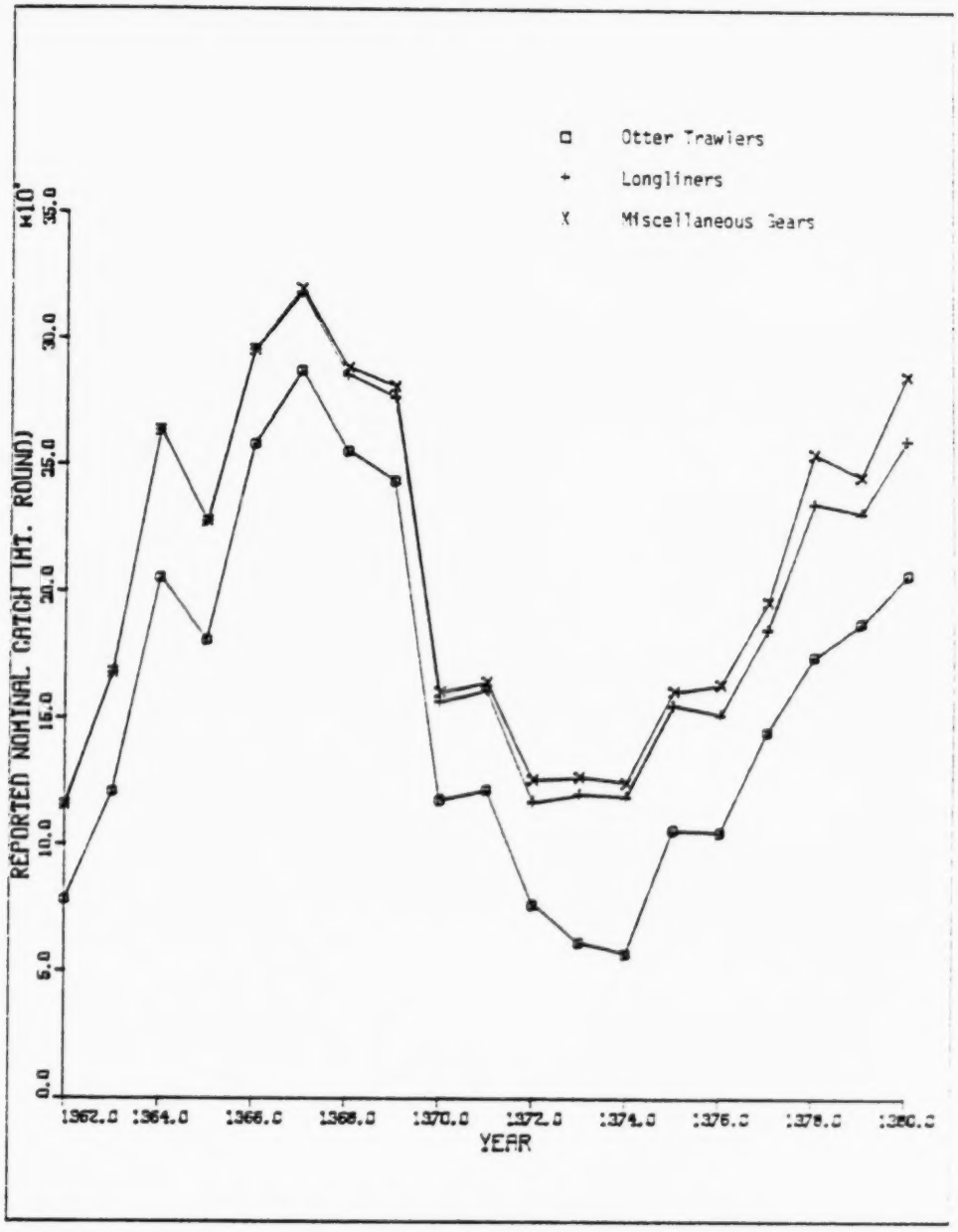


Figure 2. Reported nominal catch (mt x 10^{-3}) of 4X haddock by Canadian fishery

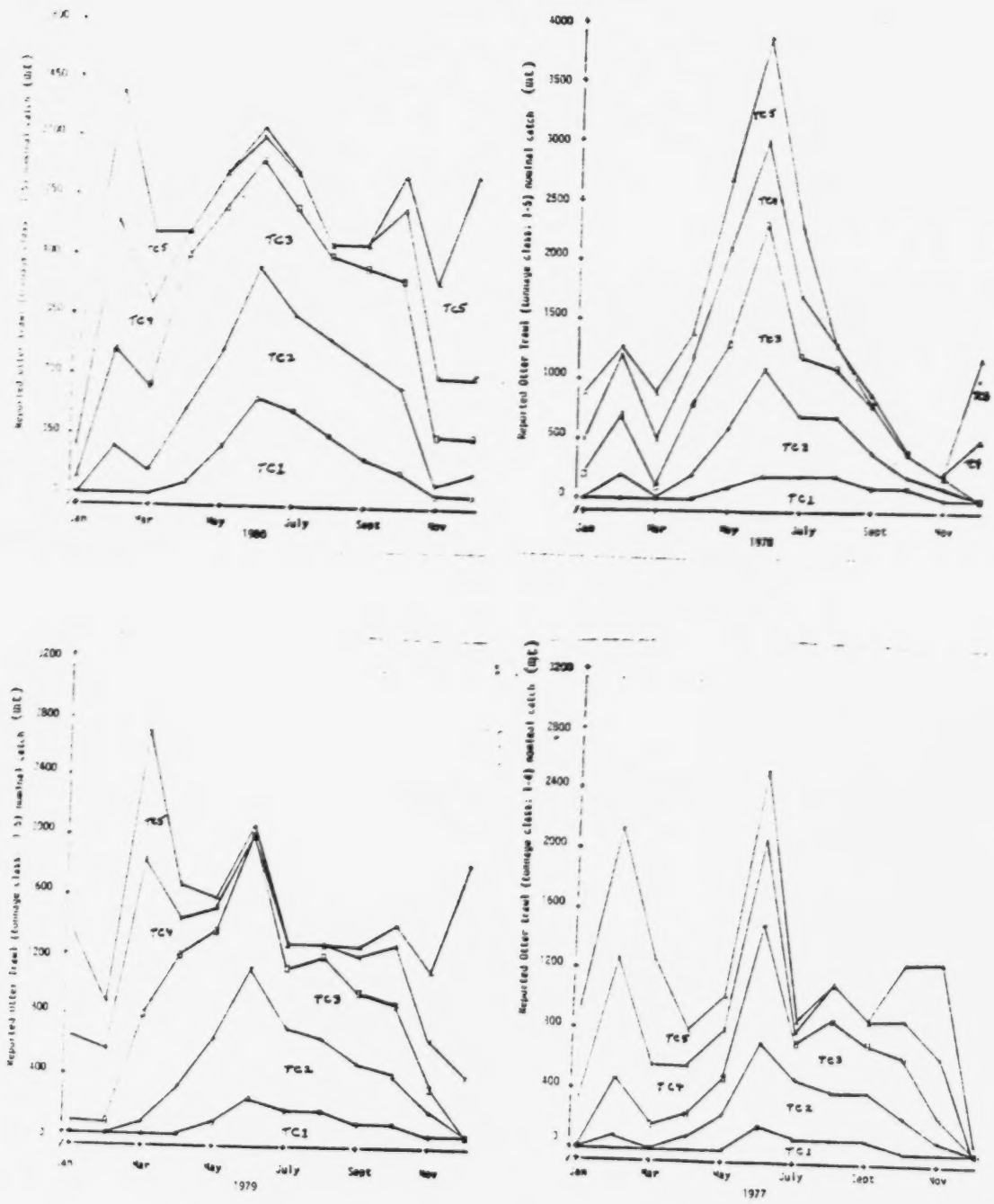


Figure 3. Distribution of landings by Canadian otter trawlers by month for the years 1977-1980

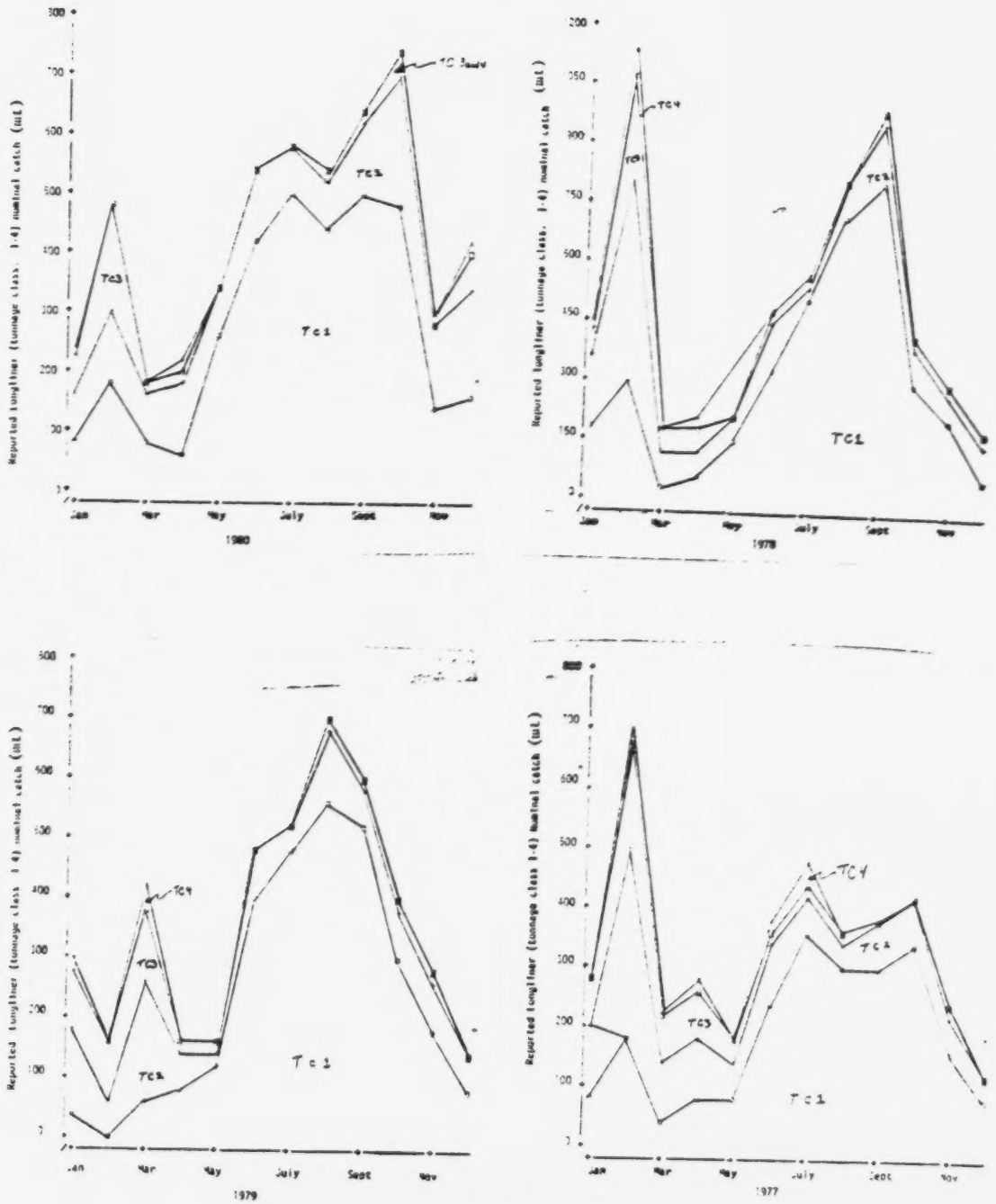


Figure 4. Distribution of landings by Canadian longliners by month for the years 1977-1980

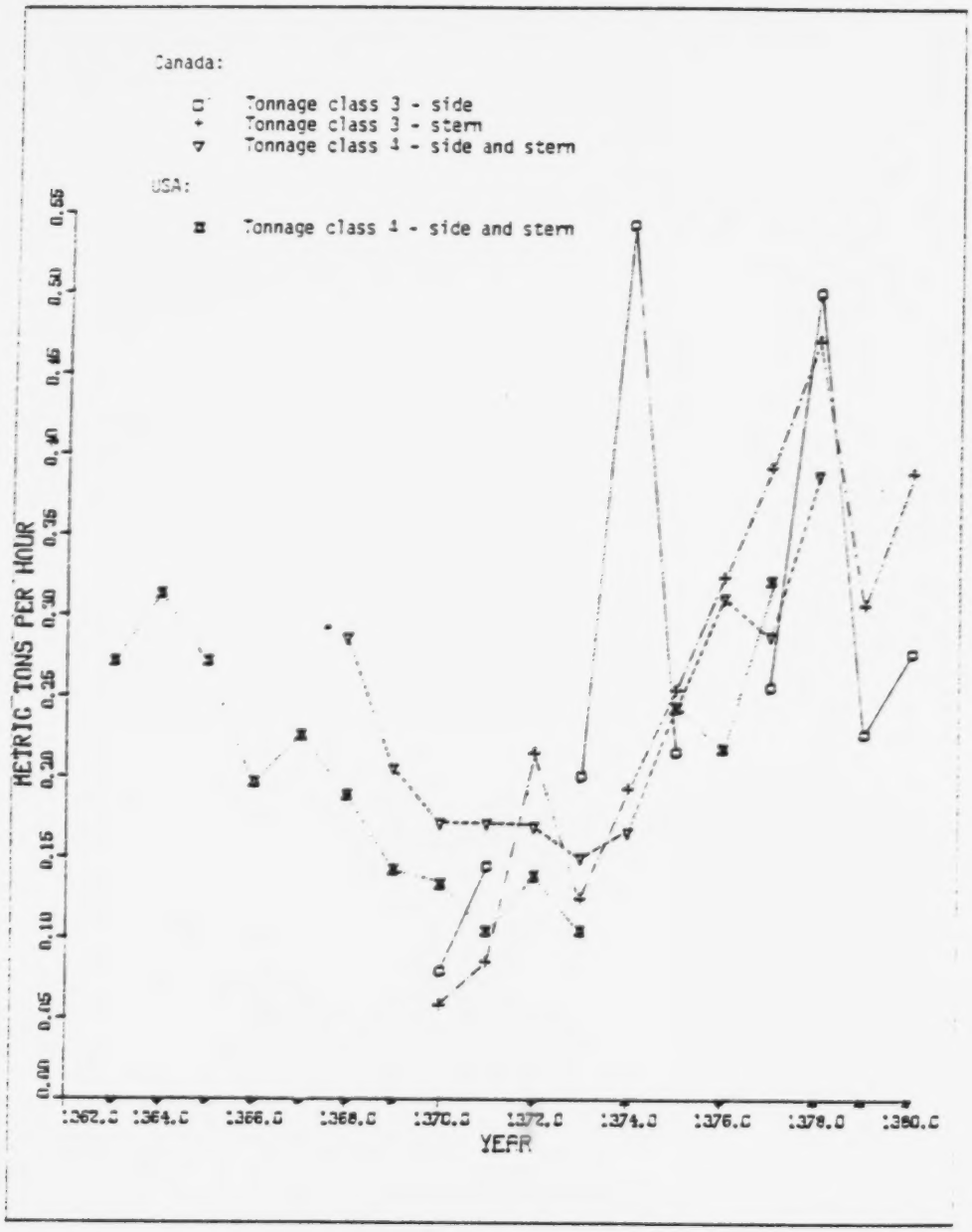
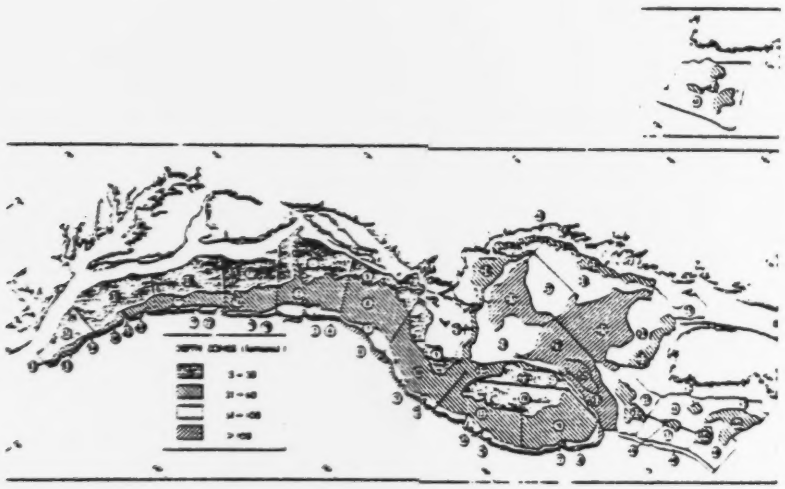


Figure 5. Trends in commercial catch rates observed in Canadian and U.S. otter trawl fisheries since 1963. (Gaps indicate unobserved periods)

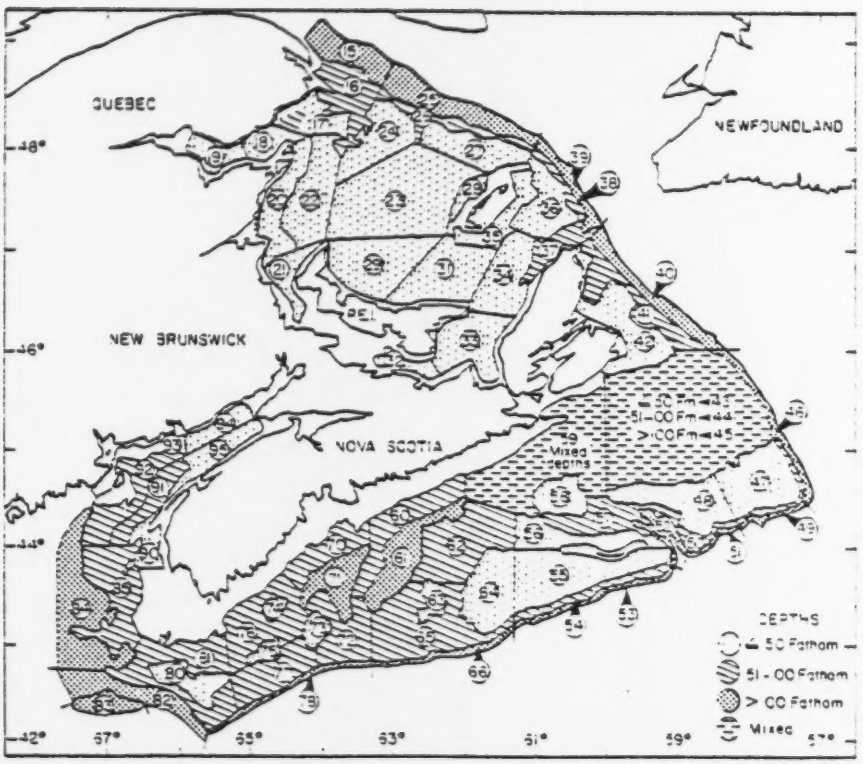
Figure 6. Stratification schemes used during U.S. fall (A) and Canadian (B) bottom trawl surveys

(A)



Sampling strata used in spring and fall NEA groundfish surveys. Strata 41, 42 (ouksat) used until 1970 when switched to strata 41-49, corresponding to Canadian strata.

(B)



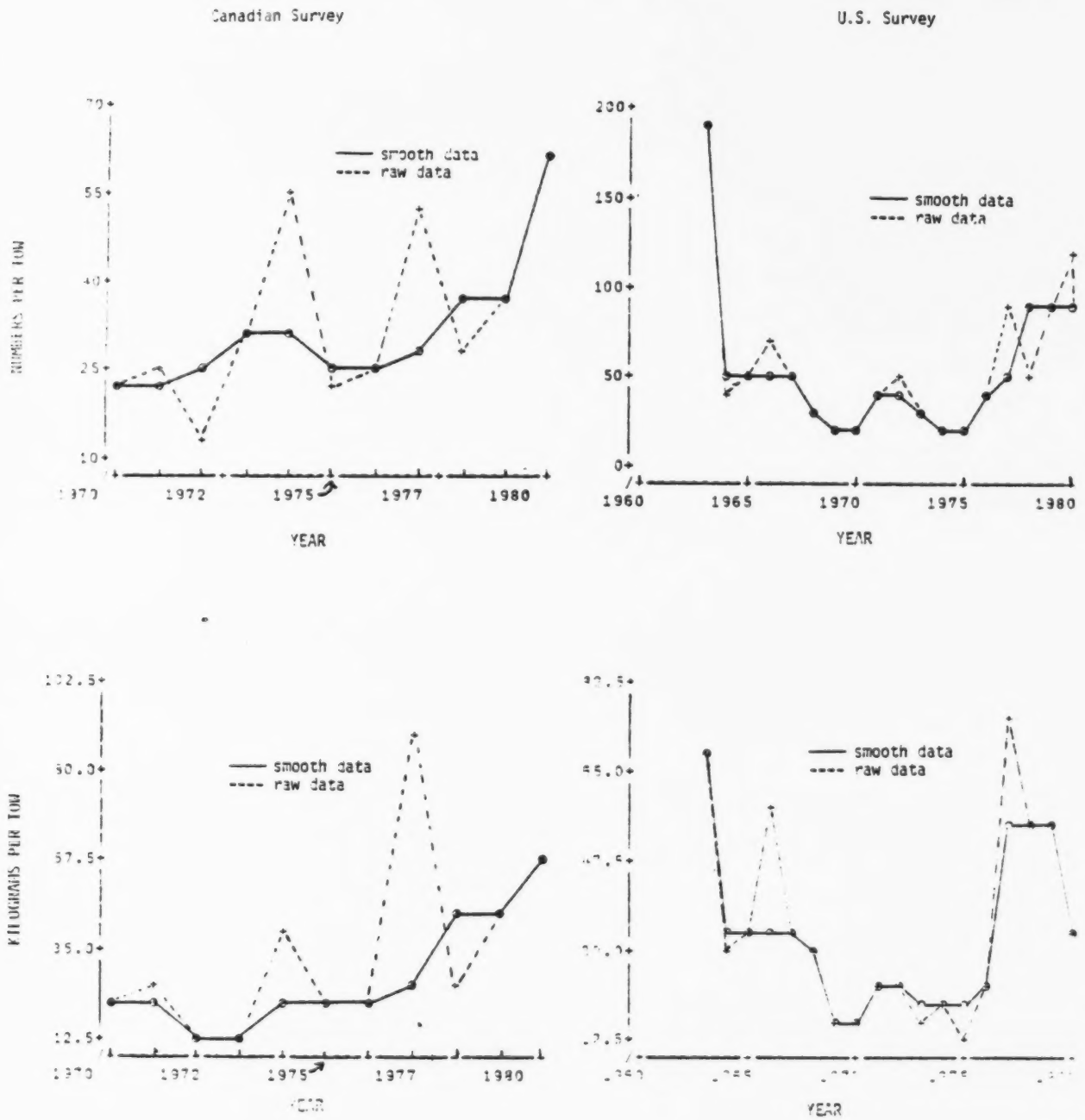


Figure 7. Trends in abundance of 4X haddock stock as determined by Canadian and U.S. bottom trawl surveys. Smoothing done by 3 year median.

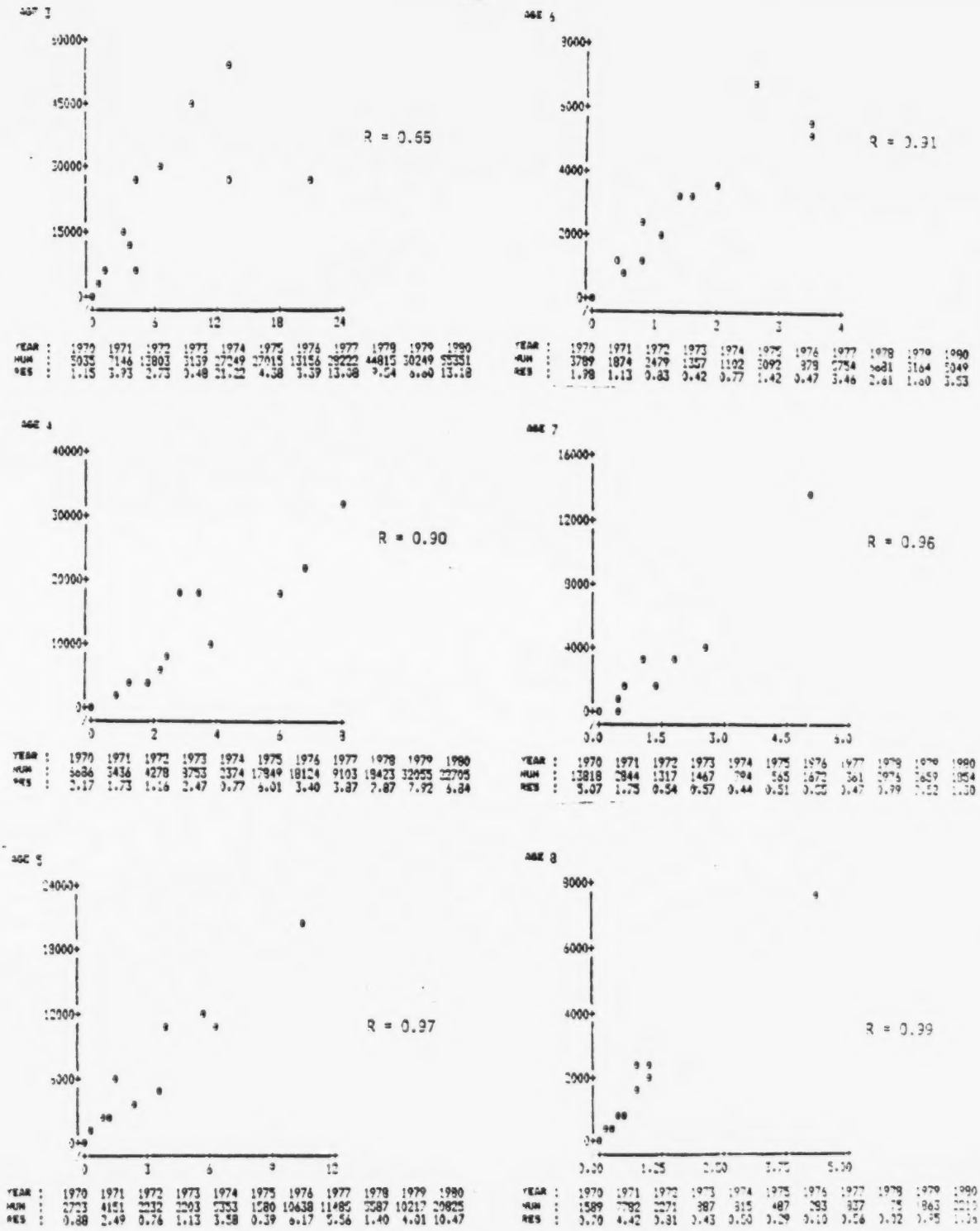


Figure 8. Survivor midyear population numbers versus Canadian research survey numbers per tow at age. Num is Y axis and Res is X axis.

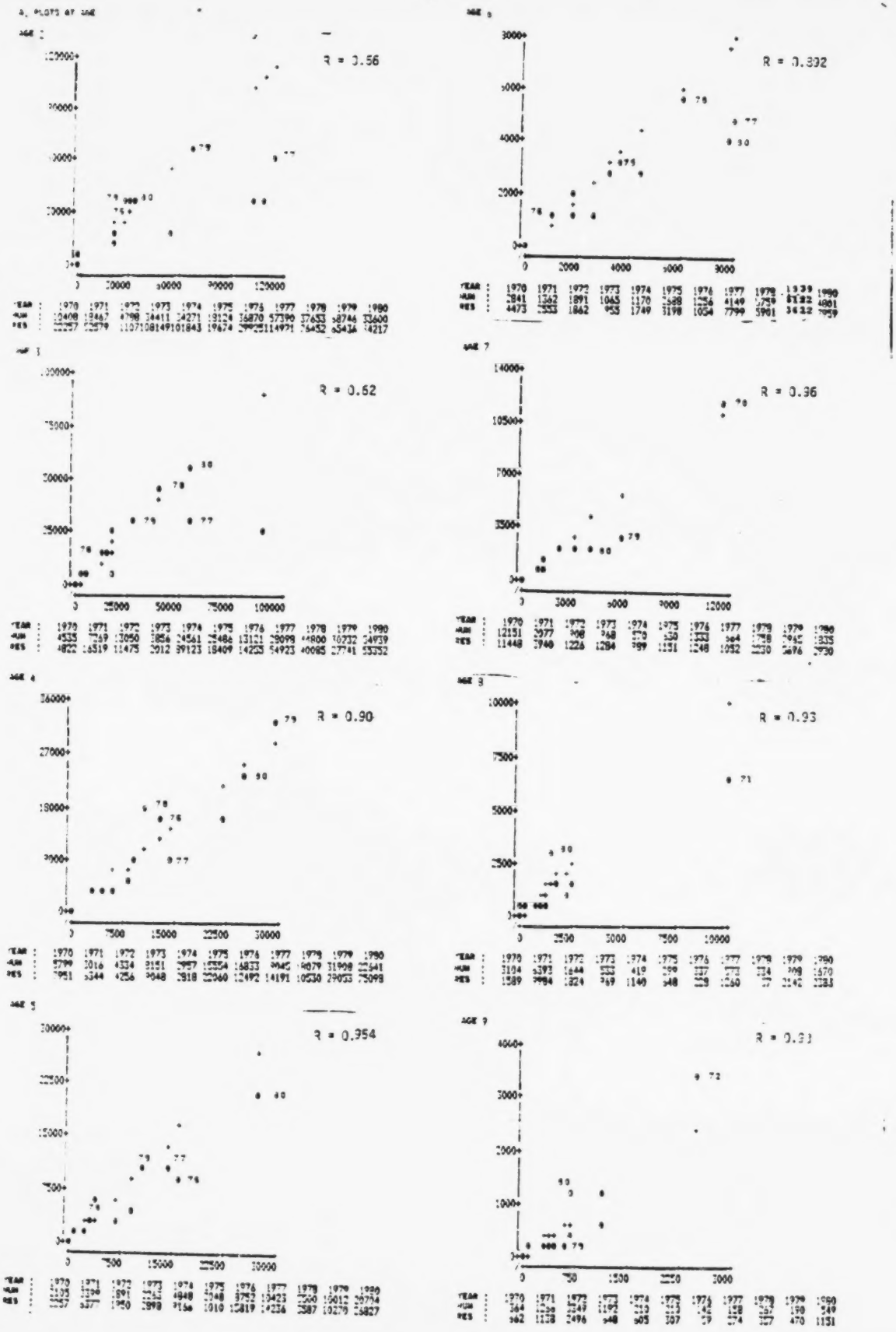
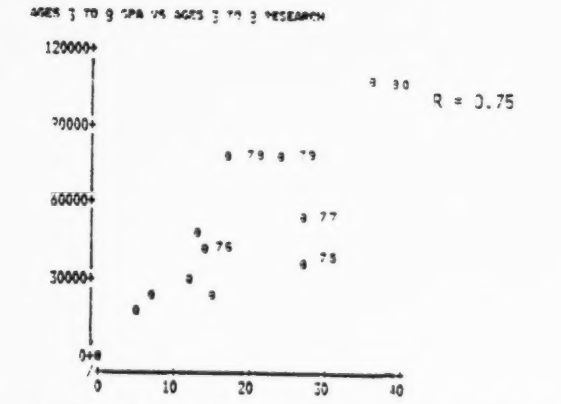
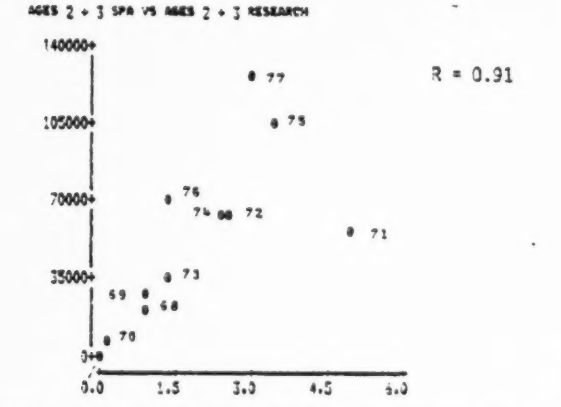


Figure 9. Comparison of survivor predicted and cohort analysis predicted population sizes at age for Option 1 (Num is Y axis and Res is X axis).





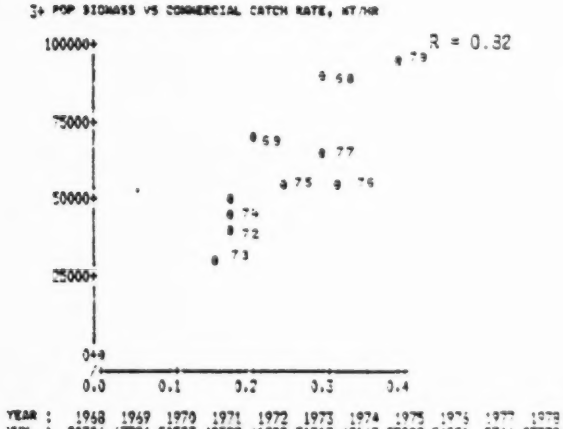
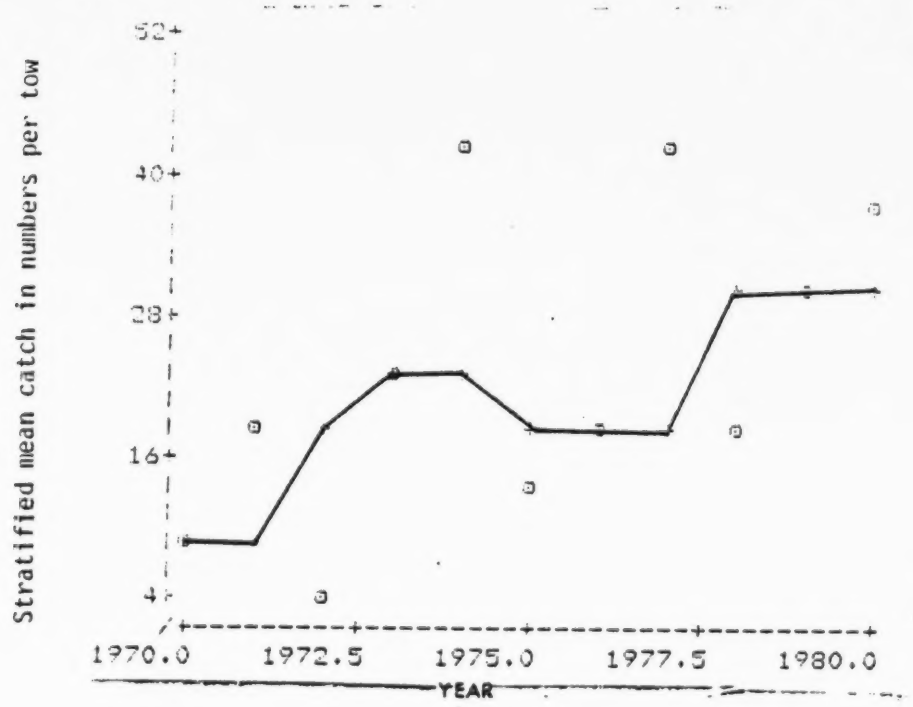


Figure 10. Standard relationships examined to adjust Conort Analysis (Option 1). (Num is Y axis and Res and Com are X axis).

Figure 11. Comparison of rough and smoothed (by median) 2-5 and 6+ research numbers per tow (Canadian survey only)

A. Ages 2-5



B. Age 6+

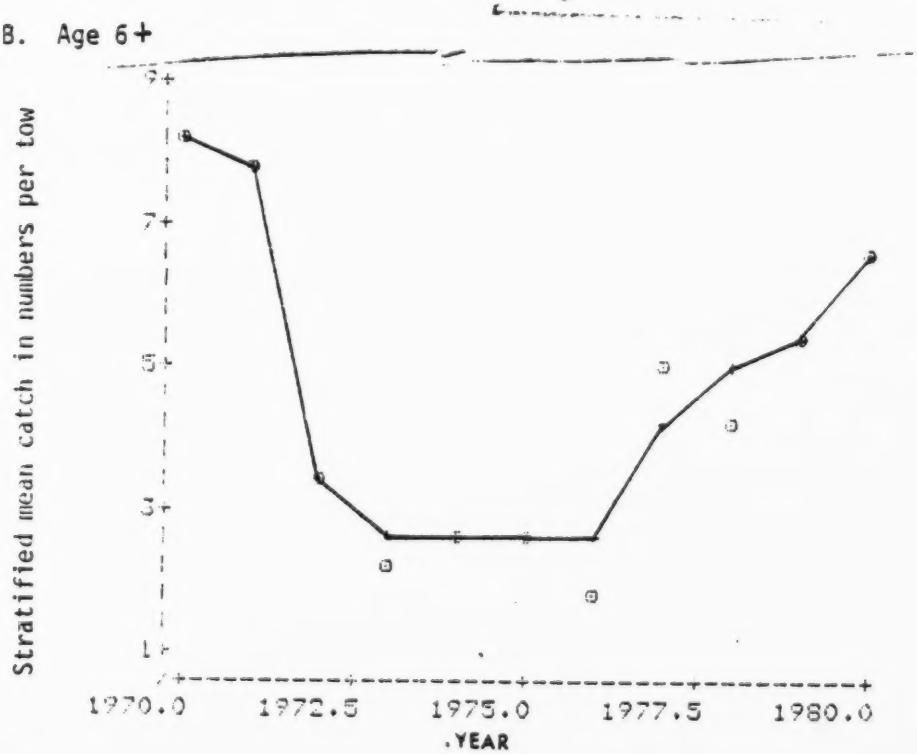
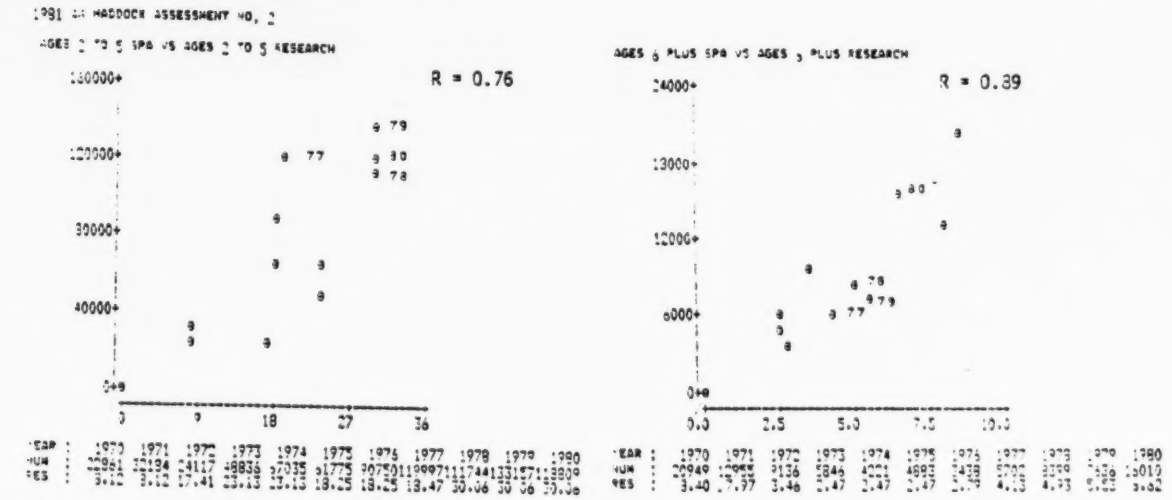


Figure 12. Standard relationships used in generating cohort analysis for option 2 (standard assessment procedure). (Num is Y axis and Res is X axis).


1981 SA HADDOCK ASSESSMENT NO. 2
AGES 2 TO 5 SPA VS AGES 2 TO 5 RESEARCH
R = 0.76
AGES 6 PLUS SPA VS AGES 3 PLUS RESEARCH
R = 0.89
AGE 1 + 2 SPA VS AGE 2 + 3 RESEARCH
R = 0.94
3+ POP BIOMASS VS COMMERCIAL CATCH RATE, AT SA
R = 0.91

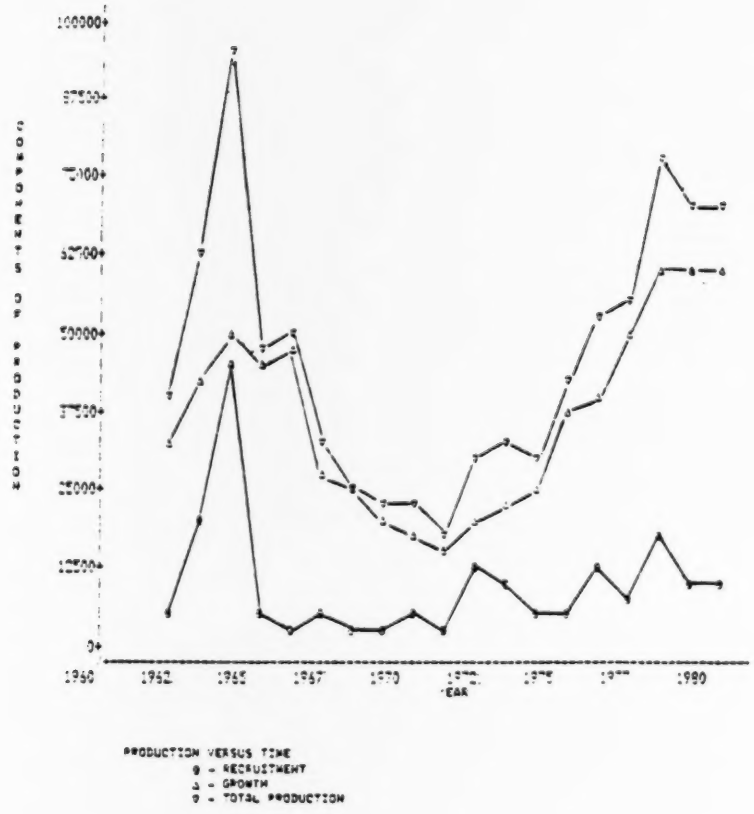


Figure 13. Variations in components of stock production (mt) during the 1962-80 period.

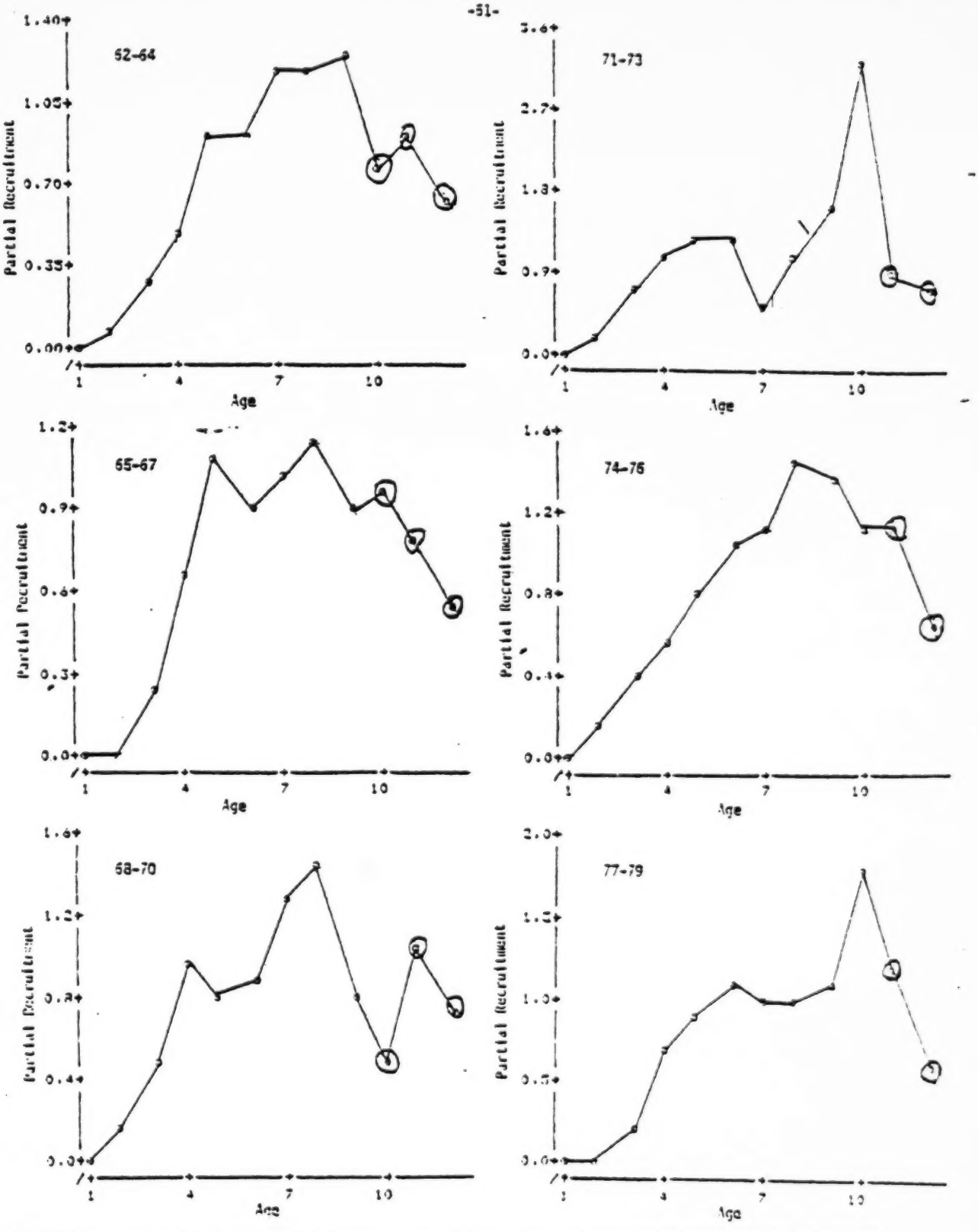


Figure 14. Change in partial recruitment at age during 1962-79 period. The circled points were dropped from the analysis.

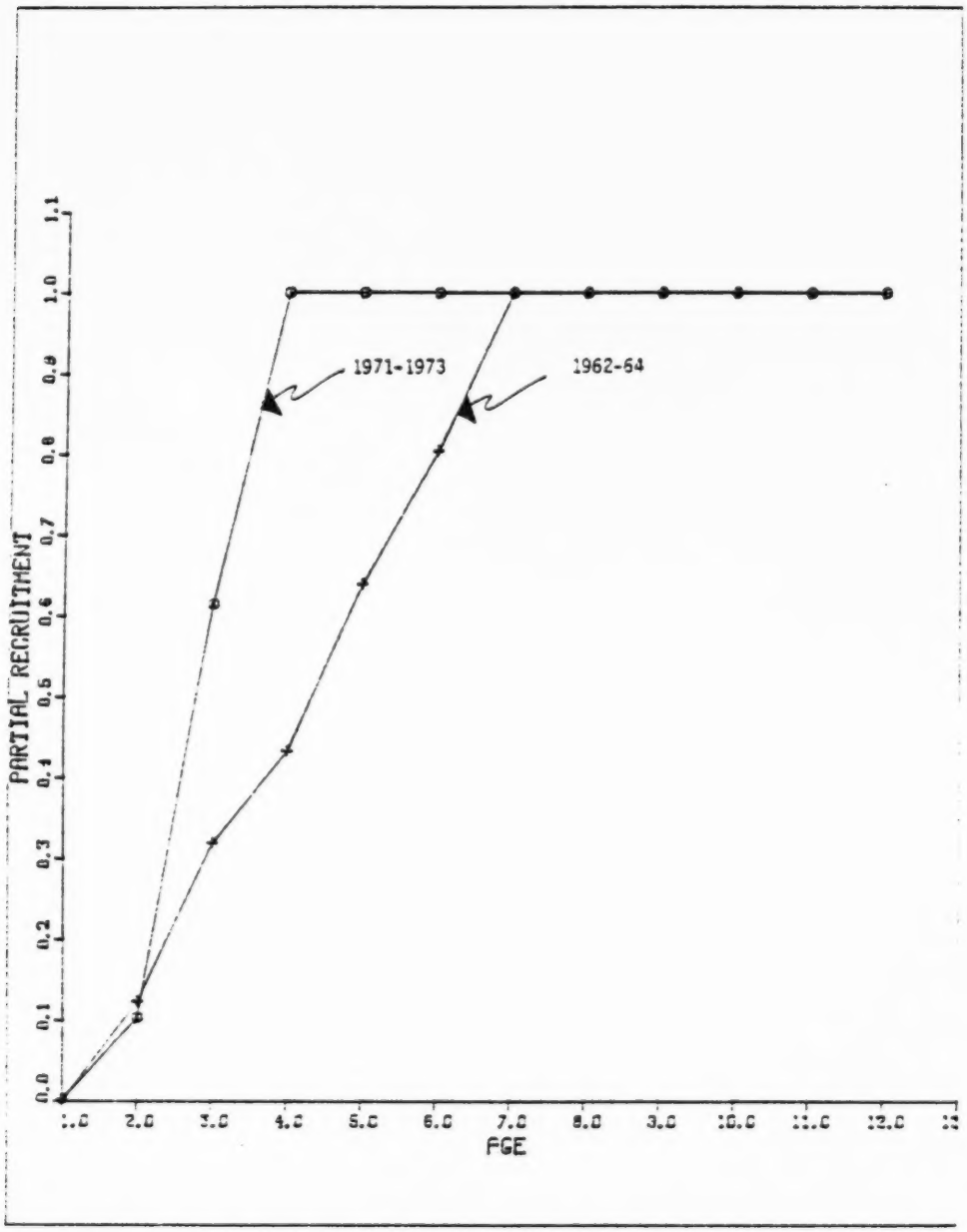


Figure 15. Observed extremes in the partial recruitment pattern for 4X haddock since 1962, as derived from the final conort analysis.

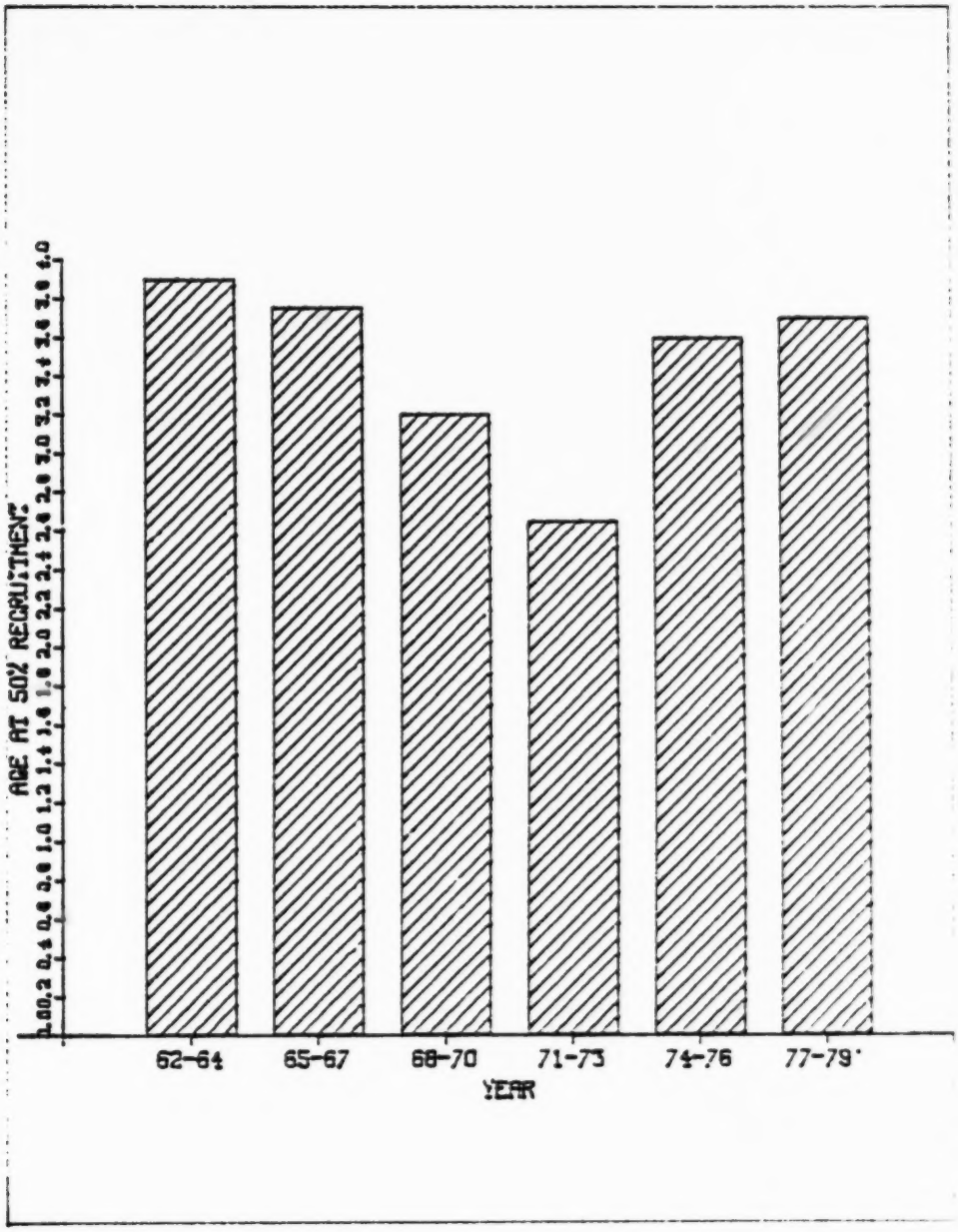


Figure 16. Observed pattern in the age of 50% recruitment to the fishery since 1962 as derived from final cohort analysis.

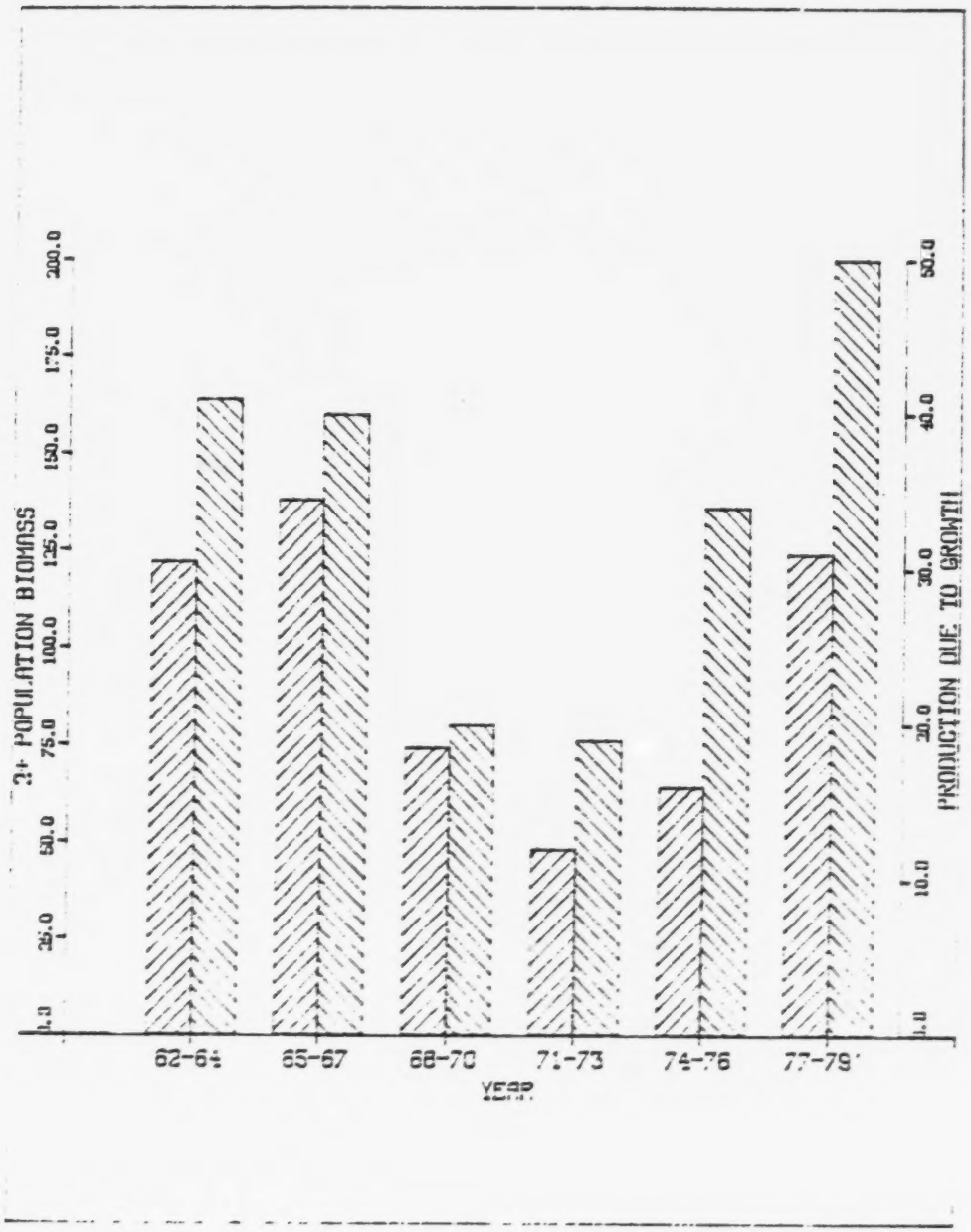


Figure 17. Observed patterns in 2+ population biomass and total production (growth component only) since 1962, as derived from final cohort analysis. (Bar on left is biomass and bar on right is production).